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FIFTIETH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS

FOR FISCAL YEAR ENDED NOV. 30, 1912.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

I herewith submit my annual report as president of the Massachusetts Agricultural College.

Each administrative officer has been asked to present a résumé of the year's work coming under his jurisdiction, and this material has been freely utilized in the present report. Following the precedent of a year ago, the report divides itself into three fairly distinct portions: —

1. A Review of the Year (page 5).
2. A Statement of Immediate Needs (page 23).
3. The Relation of the College to the Organization of Massachusetts Agriculture and Country Life (page 28).

These discussions are followed by the usual data concerning students, etc., and by the annual report of the treasurer of the institution.

A REVIEW OF THE YEAR.

ATTENDANCE.

The attendance of students enrolled in the four years' course at this date is 502, an increase of 25 over the enrollment of a year ago. In addition to this enrollment there are 22 members of the graduate school, and 31 students registered in college classes as "unclassified" students. Therefore, the total number of students doing work of college grade is 555, an increase of 34 over the total enrollment of last year. The entering class this fall numbered 184, a small increase over the number entering last year. (See Table I.)

Nearly 86 per cent. of those entering this year come from Massachusetts, and 8 other States are represented. The proportion of non-residents does not seem to have decreased, although the rule requiring a tuition fee from such students is now in force.

Every county in Massachusetts, with the exception of Nantucket, is represented in the present freshman class, Middlesex County sending the largest number, which is 34, or nearly 22 per cent., of the total number entering. (See Table V.)

One-fifth of the class are undecided as to their intended vocation; over one-third of the entire class express their intention of following some line of professional agriculture or horticulture as their life work, and about two-fifths more signify their intention of entering some vocation in practical agriculture or horticulture; nearly 94 per cent. of those having made a decision, therefore, intend to follow an agricultural vocation. Twenty-six per cent. of the fathers of the members of the freshman class are engaged in agriculture or horticulture, and about the same per cent. are business men. Approximately one-third of the class come from farms, and two-fifths have had no farm experience whatever. The average age of the entering class is 19.22 years. All of these statistics show practically the same results as those compiled for the class entering one year ago. (See Table V.)

Appropriations.

The trustees presented to the Legislature of 1912 requests for special appropriations amounting to approximately $386,000, the principal items in the list being an agricultural building, a students' dormitory, an addition to French Hall, and an addition to Draper Hall; of this amount $80,000 was granted, providing for the addition to Draper Hall, sewers, repairs, improvements and equipment. An increase of $109,000 in current annual appropriations was asked, and a large portion of it was granted, making the total annual income from the State $250,000. (See Table II.)

Construction and Repairs.

Six buildings have been completed during the past year, namely, the dairy building (Flint Laboratory), completed about the middle of August at a cost of $75,000, the apiary, completed in June at a cost of $3,000, and four much-needed buildings for the poultry department.

There have been numerous repairs and improvements during the year, probably the most noticeable of which is the painting of many of the college buildings, in colors recommended by our consulting architect. For example, several of the frame buildings have been painted a colonial gray, trimmed with "M. A. C. white."

One of the most needed improvements has been the building of the extension to the dining hall. This change is not quite completed. The addition provides a fine separate lunch room, and also increases the seating capacity of the main dining hall by 120. The maximum capacity of the dining quarters is now not far from 800.

Other improvements have been the remodeling of the offices of the treasurer in south college, the refitting of the laboratory on the third floor of the chemical building, the fitting up of a new bacteriological room in the basement of the veterinary building, the enlargement of the agronomy laboratory in south college; also an extension to the power plant which was very much needed and which gives the necessary room for storage for general supplies. There have also been many minor repairs and improvements.

Commencement.

The annual commencement occurred June 19. At that time the degree of Bachelor of Science was conferred on 83 men, thus making the class about a third larger than any class previously graduating. The college also conferred the degree of Master of Science on one candidate, and the degree of Doctor of Philosophy on one. Hon. Charles W. Garfield of Grand Rapids, Mich., delivered the commencement address on "The Business Conscience." The Lieutenant-Governor, Hon. Robert Luce, was present as the representative of the Commonwealth. The attendance at the alumni dinner was 230.

Summer Conference.

The summer school of 1912 was omitted. There was held, however, the third annual "Conference for Rural Leaders," the enrollment at which was 184. In this connection there was for the second year a large and interesting exhibit of rural social work, illustrating various forms of the service which is being undertaken for the betterment of rural communities.

The conference this year was not only very satisfactory in its program and in the attendance, but it was particularly notable by reason of the fact that it was the result of the co-operation of a number of different institutions and agencies interested in country life, the college serving chiefly as a clearing-house by which these institutions participated in the program. The following organizations co-operated with the college and were officially represented: Federation of Churches of Massachusetts; State Board of Education; Free Public Library Commission; Massachusetts Civic League; State Board of Health; County Work of Y. M. C. A.; County Work of Y. W. C. A.; New England Home Economics Association; the Russell Sage Foundation; the Massachusetts Board of Home Missions; Smith's Agricultural School; American Civic Association; New York Child Welfare Exhibit; Massachusetts Society for Prevention of Cruelty to Children.

THE WINTER SCHOOL.

The attendance at the winter school of 1912 was 131, this number being slightly larger than that of the previous year. The poultry course, which was given during the last two weeks of the winter school, brought an additional number of persons to the college. At the close of the winter school the annual farmers' week was held; over a thousand people registered during these three days of instruction.

VISITS OF OUTSIDE ASSOCIATIONS.

During the year numerous associations, not officially identified with the institution, have held meetings at the college; the following is a list, doubtless incomplete, of such meetings: —

February	7, 8.	Apiary Inspectors of Northeastern United States and Canada.
March	5.	Tenth District Massachusetts State Poultry Association.
March	10.	Connecticut Valley Breeders' Association.
March	13.	Massachusetts Dairymen's Association.
March	15.	Massachusetts Sheep Breeders' Association.
June	13.	Hampshire, Hampden and Franklin Beekeepers' Association.
June	26, 27.	Library Institute (Auspices of Free Public Library Commission).
October	14.	Hampshire, Hampden and Franklin Beekeepers' Association.

THE MAJOR SYSTEM.

At the beginning of the current college year a system of major subjects became effective. This is an arrangement whereby at the close of the sophomore year each student is required to elect a specific subject in one of those departments offering work organized as a major. During the junior and senior years the student is required to take a minimum of thirty hours' work in his major subject, a minimum of fifteen hours in the divisions of the humanities and rural social science, and a minimum of fifteen hours additional which may be elected at will by the student.

Each student is under the supervision of a major adviser, who ordinarily is the head of the department offering the major course.

At present the following subjects are open as major courses; the titles of the major courses, and the number of juniors electing each major, are indicated in the table (obviously, the major system is not yet in complete operation, owing to the fact that members of the present senior class were unable to elect a major in the prescribed manner): —

Agriculture,	11
Agronomy,	2
Animal husbandry,	11
Dairying,	2
Poultry husbandry,	3
General horticulture,	4
Floriculture,	5
Forestry,	–
Landscape gardening,	18
Pomology,	25
Agricultural chemistry,	11
Economic entomology,	6
Plant physiology and pathology,	1
Agricultural education,	3
Total,	102

NEW APPOINTMENTS.

The following appointments to major positions on the teaching and extension service staff have been made by the trustees during the year: —

Charles E. Marshall was elected director of the graduate school and professor of microbiology. Dr. Marshall comes from the Michigan Agricultural College, where for many years he has been head of the department of bacteriology. Dr. Marshall was trained chiefly at the University of Michigan, from which he holds the degree of Doctor of Philosophy. At the Michigan Agricultural College he developed the work of his department both in scientific investigation and in the solution of practical problems confronting the farmers of the State. He was also vice-director of the experiment station. Dr. Marshall is one of the foremost microbiologists of the country, is an active leader in many scientific associations, and is a recognized authority in the department of learning to which he gives his chief attention.

William D. Clark was elected professor of forestry in place of Associate Professor Moon, resigned. Professor Clark graduated from the classical course of Yale University and from the forestry school at the same institution. He has had a wide experience in forestry, which has taken him to many forests of the United States, including those of Porto Rico, Texas and the Rocky Mountains. For the past three years he has been connected with the school of forestry at the Pennsylvania State College.

Ernest Anderson was elected assistant professor of general and physical chemistry. Dr. Anderson received the degree of Bachelor of Arts at Trinity College, Texas, in 1903. Later he graduated at the University of Texas and pursued graduate study at that institution. In 1906 he entered the University of Chicago as an advanced student in chemistry and as an assistant on the teaching force of that department. In 1909 he was granted the degree of Doctor of Philosophy from that university. Dr. Anderson's work, in addition to that of teaching, has led him into chemical research under one of the foremost research chemists in the country.

Ezra L. Morgan was appointed community field agent in the extension service. Mr. Morgan was reared on a farm in the middle west, and graduated from the McKendree College, Ill., in 1904. Subsequently he spent six years in county Y. M. C. A. work. For the past two years he has been engaged in graduate study in economics and rural sociology at the University of Wisconsin, which institution granted him the degree of Master of Arts in 1912.

Orion A. Morton was elected to a vacancy in the department of agricultural education occasioned by the resignation of Floyd B. Jenks. His work is chiefly in the extension service and will consist in part of the development of boys and girls' clubs throughout the State. Mr. Morton is a normal school graduate and has spent several seasons at the summer schools of the Hyannis Normal School, the Massachusetts Agricultural College, and the Teachers' College, New York City. He was for many years superintendent of public schools at Marlborough, Mass., where he made a notable reputation as an able administrator and as an educator of liberal views.

Henry E. Smith was elected assistant professor of English. Professor Smith received his advanced training at the University of Chicago and at Yale University where he earned the degree of Master of Arts. He has had wide experience as a teacher, having served on the faculty of the North Dakota Agricultural College, the Washington State Normal School, Tabor College, Iowa, and Westminster College.

The following-named instructors and other officers of the institution have been engaged during the year: —

In the Academic Departments.

POSITION.	Name.	Institution from which graduated, and Degrees.	Year of Graduation.
Assistant in chemistry,	Robert H. Bogue,	Tufts College, B.Sc.,	1912
Instructor in poultry husbandry.	Abbott A. Brown,	University of Wisconsin, B. Sc. Agr.	1912
Instructor in pomology,	Walter W. Chenoweth,	University of Missouri, M.Sc., B.A.	1912
Buttermaker,	Samuel Coons,	- -	-
Assistant in physical education.	William J. Fitzmaurice,	- -	-
Instructor in agronomy,	Elmer M. McDonald,	University of Illinois, B.Sc. Agr.	1910
Instructor in English and public speaking.	Walter E. Prince,	Brown University, B.A., M.A.	1907

In the Experiment Station.

Assistant chemist,	Carlos L. Beals,	Massachusetts Agricultural College, B.Sc.	1912
Secretary to the director,	Benjamin G. Southwick,	Massachusetts Agricultural College, B.Sc.	1912
Assistant in horticulture,	Howard A. Turner,	Massachusetts Agricultural College, B.Sc.	1912

In the Extension Service.

Position.	Name.	Institution from which graduated, and Degrees.	Year of Graduation.
Expert in farm management,	Herbert J. Baker,[1]	Massachusetts Agricultural College, B.Sc.	1911
Supervisor of correspondence courses.	Arthur T. Dailey,	University of Vermont, B.Sc.	1911
Field agent, Barnstable County.	Albert W. Doolittle (part time).	-	-
Instructor in pomology,	Ralph W. Rees,	Oregon Agricultural College, B.Sc.	1911

[1] Transferred from the experiment station.

In the Clerical Force.

Cashier, treasurer's office,	Harold A. Crane.
Clerk, department of chemistry,	Miss Lina Fisher.
Stenographer, experiment station,	Miss Grace E. Gallond.
Clerk, extension service,	Miss Hannah Griffin.
Clerk, department of poultry husbandry,	Miss Mary R. Kingsbury.
Clerk, dean's office,	Miss Virginia Noble.
Stenographer, division of horticulture,	Miss Gladys E. Russell.

Thomas Canavan.

The following resolutions on the death of Mr. Thomas Canavan, which occurred July 14, 1912, were adopted by the trustees' committee on buildings and grounds and subsequently by the Board of Trustees: —

Mr. Thomas Canavan, who passed away July 14, 1912, was for forty-five years the faithful and loyal servant of the Massachusetts Agricultural College. His efficient services were always highly valued; his personality gained for him universal respect, and his kindly attitude toward all endeared him to those with whom he came in contact.

The trustees of this institution join his many friends among alumni, faculty, and students in mourning his loss, and hereby desire to record their expression of sympathy to his daughter and other relatives in these days of sorrow.

Resignations.

S. Francis Howard, after a year's leave of absence which was spent in study at Johns Hopkins University, and which gained for him the degree of Doctor of Philosophy, resigned as assistant professor of chemistry. Professor Howard has devoted fourteen years to efficient work in teaching in the department of chemistry. As a loyal alumnus, hard-working teacher, and earnest man, Professor Howard had made a splendid record of service.

Frederick F. Moon resigned as head of the department of forestry to accept a similar position at Syracuse University. Professor Moon succeeded in his two years' incumbency of this position in establishing the department on a sound basis and the teaching on a high level of effectiveness and enthusiasm.

Floyd B. Jenks resigned his position in the department of agricultural education to accept a call as expert in agricultural education in the United States Bureau of Education. Professor Jenks had laid good foundations for a plan of organized agricultural education as a part of the State public school system.

The following table indicates all resignations that have occurred during the year: —

POSITION.	Name.	Successor.
Assistant in chemistry, ...	Harold S. Adams, . .	Robert H. Bogue.
Secretary to the director of the experiment station.	Herbert J. Baker,[1] . .	Benjamin G. Southwick.
Clerk, division of horticulture, . .	Helen Granger, . .	Gladys E. Russell.
Assistant professor of chemistry, .	S. Francis Howard, . .	- -
Supervisor of correspondence courses, .	Albert R. Jenks, . .	Arthur T. Dailey.
Assistant professor of agricultural education.	Floyd B. Jenks, . .	Orion A. Morton.
Associate professor of forestry, . .	Frederick F. Moon, . .	William D. Clark.
Extension instructor in pomology, .	Alvah J. Norman, . .	Ralph W. Rees.
Assistant, experiment station, . .	George R. Pierce, . .	- -
Secretary to director of experiment station.	Benjamin G. Southwick, .	- -
Assistant in horticulture, experiment station.	Howard A. Turner, . .	- -
Assistant in chemistry, ...	William A. Turner, . .	- -
Instructor in English and public speaking.	Howard DeF. Widger, .	Walter E. Prince.

[1] Transferred to extension service.

Change in Title of Officers of the Institution.

NAME.	Former Title.	Present Title.
Edward M. Lewis, . .	Assistant dean and assistant professor of literature.	Associate dean and professor of literature.
Alexander E. Cance, .	Assistant professor of agricultural economics.	Associate professor of agricultural economics.
Clarence E. Gordon, .	Assistant professor of zoölogy and geology.	Associate professor of zoölogy and geology.
Sidney B. Haskell, . .	Assistant professor of agronomy,	Associate professor of agronomy.
Charles A. Peters, . .	Assistant professor of inorganic and soil chemistry.	Associate professor of inorganic and soil chemistry.

The Year in the Departments of Instruction.

In the Division of Agriculture. — Progress has been made in furnishing the division of agriculture with much-needed room and equipment. Flint Laboratory, the new dairy building, was finished and available for use Sept. 1, 1912; it has been made temporary headquarters for the division, furnishing offices for all the departments and several classrooms and laboratories other than those used by the dairy department. The whole building, however, should, in the very near future, be available for the uses for which it was designed, namely, dairy instruction and investigation. The equipment and machinery for this building, including refrigerating machinery, have been installed and will give opportunity for the best instruction in all branches of the dairy business. The teaching force of this department has been increased by the addition of an assistant who will devote most of his time to the laboratory work.

In the department of animal husbandry, the dedication of the Grinnell Arena during farmers' week should be mentioned. The work of the department has also been improved by the construction of a sheep barn, and the purchase of sheep for instructional purposes. A pair of pure bred Percheron mares have also been purchased during the year.

The equipment of the department of poultry husbandry has been increased by the addition of a laboratory building, a breeding house, the completion of a long laying house and facilities for experimental incubation, apart from the student incubator cellar. The increasing work of this department has demanded the services of an additional instructor. Through the extension office many calls come for the services of the head of this department, and the additional teaching assistance will give him more time to devote to this outside work.

The equipment of the department of agronomy has been somewhat increased by fitting up the laboratory in the basement of south college, formerly used by the department of dairying. This increase, however, does not keep pace with the increased registration of students. The instruction force of this department has been supplemented by the employment of another instructor.

The department of farm administration has begun a series of field investigations in farm management, under a co-operative arrangement between the extension service and the office of farm management of the United States Department of Agriculture.

The addition of 62 acres of land adjoining the south boundary of the college farm has not heretofore been noted. This is excellent land, but not now in a high state of cultivation; a good deal of it has been cleared during the year and will be brought into good tilth as soon as possible.

In the Division of Horticulture. — The work in the various departments of this division has, during the past year, progressed along much the same lines as followed formerly. The gardens, orchards and greenhouses are used extensively as laboratories and are considered as of utmost value in augmenting the classroom instruction given in the different studies. The new fruit-packing and storage building is constantly proving its worth as a laboratory for those specializing in pomology.

The department of landscape gardening is now entirely responsible for the care of the college grounds; this arrangement has been observed for about three years and the advantage of assigning the full responsibility to one department is constantly in evidence; a marked improvement has been noted during the past year in the general appearance of the lawns, walks and drives of the campus.

In the Division of Science. — The chairman of the division states that "there has been no change in organization since the last catalogue was prepared. The several departments are working in harmony, although necessarily very independently of each other as relates to the collegiate work.

"I am of the opinion, gained from talks with the men at the head of the several departments, that the most pressing need at the present time, from the academic point of view, is a major course in pure agricultural science. By this is meant a course that would fit graduates to take up lines of scientific work in agricultural or other scientific institutions, and enable them to hold their own with graduates of other institutions that make a specialty of fitting men for scientific teaching and investigation."

In the Division of the Humanities. — The division, in the opinion of its head, is in a "state of flux until it is seen how the major system of courses will operate. There may be an elimination of some courses unfit to survive by the gravitation of students in search of the best work for their minor requirements. It will take a year or two more to see clearly how the elective courses will tend."

There are several courses in the division with small registration; and unless these courses are more freely elected, doubtless they should be dropped. It is important to gather equipment about the best courses, make them profitable and interesting, and use the energies of the faculty where they will count for greatest fruitage. The head of the division places emphasis upon a wider study of literature as well as on the need of increasing somewhat the opportunities for the study of general narrative history in order to enable students to get historic facts for the background of their other work.

Probably no departments of the institution appreciate the limitations of our present library facilities so fully as the various departments in this division. The library quarters are very much restricted. The ventilation is not good. There is neither room nor table space for individual work. In fact, the whole equipment is entirely inadequate for satisfactory work. A college library in no small degree determines the standing of the institution. If facilities for good library work are absent, it seriously affects the efficiency of the scholarship.

The departments feel seriously the need of a building which will house all the departments of the division of the humanities under one roof. As it is, the various departments, and even the instructors, are scattered about the campus, — many of them without definite headquarters. Under these conditions, *esprit de corps,* concentration of effort, and administrative efficiency are difficult to maintain.

In the Division of Rural Social Science. — This division consists of the three departments of agricultural education, agricultural economics and rural sociology.

In agricultural education the effort thus far in the collegiate work has been to prepare teachers for agricultural high schools. The number of men doing this work has been somewhat disappointing; this is probably due in part not only to the fact that commercial positions pay larger salaries, but that to the average man the work is more attractive. Many men are willing to teach only as a last resort. Our students, perhaps, do not yet sufficiently realize the opportunities for interesting work and helpful service that are available to the teacher of agriculture. The salaries paid are not excessive, but they are reasonably fair. It is to be said that the present enrollment in the various courses offered in the department shows a gratifying increase.

In the department of agricultural economics the main strength of the work lies at present in the course required of all sophomores. This course gives to all our students an introduction to the economic problems that confront the agricultural business. There are also advanced students who are investigating some of these problems in a specialized way.

The department of rural sociology should have an introductory course required of all students, but it has not as yet been possible to bring that about. When that is done, all our students before entering the junior year will have had an introduction to the whole field of the agricultural problem, in its practical, scientific, economic and social aspects.

There is a strong feeling on the part of the instructors in agricultural economics and rural sociology that majors should be offered in both of these departments in order that men may specialize and fit themselves for some of the new positions that are opening for men trained in these subjects.

In the General Departments. Library. — During the past year 2,535 accessions were made to the library collection; the total number of volumes now in the library exceeds 40,000. The task of recataloguing has continued with gratifying rapidity; in the last year over 7,700 books were recatalogued, and the total number recatalogued since the work was started in 1909 is 18,430.

About a year ago the library publicly announced that it was prepared to loan collections of books on agriculture and country life to libraries in the State; in ten months 37 of these circulating libraries were sent out; an average of 24 books and pamphlets were shipped each time and these were widely distributed through the local libraries.

The faculty and students now use the library to a greater extent than ever before, and are constantly making it a real educational laboratory. For this and other reasons the need of adequate library space is felt very keenly by all.

Military Science. — During the past year the regiment has been divided into two battalions of three companies each and a band; the companies average about 55 men. All the members of the three lower classes are required to drill, and at present 19 members of the senior class are electing drill, making the total enrollment in the military department 430. No men are excused permanently from drill; those physically unable to drill are required to work in the office or on the rifle ranges. The general instructions of the war department have been fully complied with; three hours of practical work a week during drill periods are required of all students enrolled in the department. In addition, theoretical instruction is given to members of the sophomore and junior classes one hour a week during the year. Great interest is still maintained in rifle practice; the indoor rifle team again won the intercollegiate championship of the United States, while the outdoor team won second place.

Physical Education and Hygiene. — The work of the department during the past year has been conducted along the following lines: —

1. The physical examination of each freshman to ascertain the condition of health and physical development, and to detect defects which may exist, especially in sight, hearing, heart and lungs. Each person thus examined is advised as to the proper form of exercise to take to suit his individual condition. The examination and interview require about thirty minutes for each man.

2. The freshman class receive instruction in physiology and personal hygiene through a course of lectures given by the physical director.

3. During the winter months the department requires three hours of physical exercise per week of each member of the three lower classes. Those men who have been found by examination to be physically normal are permitted to elect one of the several athletic activities; those who have been found to be below normal, physically, are given individual instruction. Walking trips may be substituted for physical exercise in the gymnasium; during the past year from 75 to 100 students elected this form of exercise.

4. The work of the indoor classes of from 30 to 40 men consists of gymnastic exercises and such games as basket ball and indoor baseball.

5. The physical director is general manager of athletics, supervising the arrangements for contests with other colleges, buying the supplies for the teams, assisting in the coaching, and having final control of the conduct of players and games, and encouraging the student body to compete in intramural contests.

The Graduate School.

During the year Dr. Charles E. Marshall of the Michigan Agricultural College was elected to the position of director of the graduate school. Dr. Marshall contemplates making in the near future a thorough study of the organization and work of graduate schools of agriculture and allied sciences, both in this country and abroad. After his return to the college, which will be prior to the opening of the next college year, it is expected that he will make a full report to the faculty and trustees, embodying recommendations as to the future development of the graduate school at this institution.

The Year in the Experiment Station.

I regret to report that during the spring Dr. W. P. Brooks, director of the experiment station, became seriously ill. He was immediately granted a leave of absence and is still on leave. During the autumn his convalescence has been rapid, and it is sincerely hoped that in the near future he will again be at his important post with recovered strength.

Agricultural Department. — The work of experimentation with fertilizers on various plants has gone on as in the past. The Graves' orchard yielded heavily, the estimated value of the fruit being $500. The asparagus field at Concord bore a large crop for its fourth year's cutting, and the lightness of the attack of rust that it suffered gives promise of satisfactory results next year. The cranberry bog is in excellent condition, and while the crop was light this year, a maximum yield is anticipated for next season.

Botanical Department. — The routine work of this department has been similar to that of other years, consisting of the diagnosis of diseases, determination of plants, correspondence of a technical nature, seed germination, separation and purity testing.

Department of Plant and Animal Chemistry. (*a*) During the year the research work has made substantial progress; at present, four experts give practically their entire time to this activity.

(*b*) The inspections have gone on with satisfaction; during the year over 1,100 samples of fertilizers and 1,000 samples of feedstuffs have been collected and analyzed.

(*c*) Samples of agricultural products such as milk, cream, concentrated and coarse fodders, soils, waste products suitable for fertilizing purposes, waters, vinegars and the like are constantly being received, examined and reported upon.

(*d*) Work in connection with animal nutrition includes the examination of feedstuffs, milk and butter, and in plant nutrition, the analysis of crops and soils.

Department of Entomology. — Over a thousand field tests have been made in studying the burning of foliage by insecticides. Good progress is noted in studying parasites. Observations on dates of hatching of scale insects have continued, and also the study of methods of controlling the wire worm. Experiments were for several months conducted on the onion maggot, and several commercial insecticides were tested.

In apiculture, the work on color vision of bees is progressing; photographic and numerical records have been kept. Study has been given upon an instrument for counting hive bees as they pass into a hive, and upon the transportation of bees without combs. Important observations have been made on the use of bees in greenhouses.

Department of Horticulture. — The experimental work of the year has gone on without special incident; studies on the climatology of the apple have been published during the year and constitute a notable contribution to the scientific knowledge of pomology. The work in plant breeding has been making excellent progress.

Department of Poultry Husbandry. — Three lines of experimentation are being undertaken: (1) individuality in hens, studied by trapnesting, and subsequently determining the egg-yield, percentage of fertility, and hatchability; (2) digestion experiment to determine value of a widely advertised hen food; (3) effect of food on flavor and odor of eggs.

Department of Meteorology. — The work of the year has necessarily followed the routine of previous years; co-operation with the Weather Bureau has been continued as usual, and the regular monthly issue of the weather bulletin has been kept up.

Department of Veterinary Science. — Investigation of obscure diseases of animals has been carried on in response to requests for information, as, for example, the recent definite determination of white diarrhœa in chicks.

The Year in the Extension Service.

No attempt has been made to enlarge the activities of the service during the past year, but a consistent effort has been made to organize, systematize and to put on a sounder basis the different lines of work which we are called upon to do. The work on the whole for the year has progressed in a satisfactory manner, and has unquestionably grown in the respect of the people of the State. The annual appropriation for this work was increased from $20,000 to $50,000 by the Legislature of 1912.

Considerable time has been spent in planning a type of organization which will enable every department of the college to contribute in some measure to the work of the service, and at the same time insure unity, harmony and efficiency of administration and teaching. To the end that the work of other institutions might be studied, the director made a trip to institutions in Wisconsin, Iowa, Nebraska, Kansas, Missouri, Illinois and Indiana. When the material and information obtained on this trip can be worked over, valuable suggestions for the work here will be forthcoming.

New Features of the Work during 1912.

A very successful apple-packing school was conducted by the department of pomology, assisted by an expert from Hood River, Ore.

Extension schools five days in length were held in five towns. Judging from the reports which have come from these communities, these schools are the best pieces of extension service carried on away from the college.

Work by the extension service in community studies has been started, involving a definite policy and program for co-operation of all agencies within communities, for social, economic, religious and educational advancement.

The boys' and girls' club work is being further organized. Exhibits and round-up meetings have been held this fall. Schools all over the State are rapidly being brought into line for work next year. The records in a contest for boys, the prizes in which will be free trips to Washington, Boston and farmers' week at Amherst, are now nearly complete.

Field agent work has been started in Barnstable County.

A definite program for work in civic improvement is being developed.

Through the generosity of a friend of the college, the services of a woman expert in home economics were given to the college for a period of three months during the year. She gave instruction in domestic science in the extension schools, and visited several towns. The need of this work was shown by its immediate popularity and the large number of requests which at once came from several communities for more of this teaching.

Fourteen stock-judging contests for boys were arranged and conducted at as many agricultural fairs. More than a hundred boys competed, and a goodly number participated in the final contest at Brockton, in which scholarships at the college were offered as prizes.

Co-operation with Other Organizations.

The policy of co-operating with other worthy organizations in any useful work which comes within the province of the agricultural college is being adhered to. Further co-operation between the organizations mentioned on pages 27–28 of the 1911 report has taken place.

New relationships have been established. This year the Pittsfield and Milford Y. M. C. A.'s will have a series of meetings. A good deal of work has been done for the western Hampshire board of trade. Assistance has been rendered the social service commission of the Massachusetts Federation of Churches. Several organizations not previously represented held meetings at the college during farmers' week.

Due to some visits of extension men to other State institutions, twenty-five farm superintendents and other officers of these institutions attended farmers' week.

A desire and willingness on the part of existing organizations all over the State to co-operate in movements for upbuilding the rural life of the Commonwealth is found to be almost universal.

So many of the recommendations made on pages 30–31 of the 1911 report still remain to be carried out that it seems almost useless to add more at the present time. Of those mentioned, the director desires to emphasize two, and to ask that these be given consideration before other things are taken up: —

1. That a travelling instructor, provided with an automobile and equipment, be engaged for demonstration work in rural districts.
2. That a woman with a training in home economics, who possesses good organizing ability, be engaged for extension work in home economics and domestic science.

There will be need of more money by the end of the present year. Every effort should be made to secure the passage by Congress of the agricultural extension bill. Even though this passes, appropriations of at least $10,000 for specific purposes in addition to what the State is now giving should be asked for in the budget that is to be made up in October, 1913.

THE IMMEDIATE NEEDS OF THE COLLEGE.

Fundamentally, the need of increased appropriations, both for maintenance and for buildings, is due in part to the growth of the college in number of students, but also in part to the increased activities of the college made necessary by the rapidly enlarging field of agricultural research, instruction and dissemination. Our understanding of the rural problem in Massachusetts is constantly broadening, and as our conception of the problem broadens, the necessity of broadening the work of the college in order to help solve the problem also develops.

No attempt is made at this point to discuss the needs of the college for increased appropriations, except those that are of immediate consequence. Perhaps the most effective way of indicating the present needs of the college is to outline the reasons that underlie the action of the trustees in formulating the legislative budget for the ensuing year.

THE LEGISLATIVE BUDGET FOR 1913.

The budget to be presented to the Legislature of 1913, as approved by the Board of Trustees at its meeting in Boston, Nov. 8, 1912, may be summarized as follows: —

For Increase in Current Annual Appropriations.

	Available for 1913.	Requested for 1914.	Increase.
Investigation,	$15,000	$30,000	$15,000
Instruction,	75,000	95,000	20,000
Repairs,	–	15,000	15,000
	–	–	$50,000

For Special Purposes.

Agricultural building,	$210,000
General improvements and repairs,	40,000
Land and sewers,	–

Statement of Reasons for Requested Increases in Current Funds.

For Investigation. — Heretofore the burden of financing investigations and experiments carried on by the institution through its agricultural experiment station has been borne chiefly by the national treasury, from which we have secured for some years about three-fourths of the annual cost of the experiment station. Last year the Legislature added $4,500 to the investigation item, with the unwritten understanding that the major part of it was to be used for investigations in poultry culture. There are, however, a great many lines of investigation applicable to the needs of Massachusetts farmers, and highly important in themselves, that are being neglected by the institution simply for lack of funds. The trustees ask, therefore, that the annual appropriation for investigation be increased from $15,000 a year to $30,000 a year. Some of the projects which it is proposed to take up with these increased funds are listed as follows: —

In floriculture: The study of certain plants with regard to their value for forcing for winter bloom; the study of factors by which the light efficiency of greenhouses may be increased; the effect of commercial fertilizers on carnations; the effect of different fertilizers on roses; co-operative experiments with regard to insect and fungous diseases troubling greenhouse plants.

In market gardening: Storage experiments with vegetables, both as regards probable preservation and market values.

In veterinary science: The study of important animal diseases along lines that are not being worked out elsewhere in the State.

In microbiology: Investigations in soil bacteriology. This is a line of work that is almost completely neglected, and yet of the utmost consequence in agricultural science.

In pomology: Spraying experiments with special reference to the aphis and curculio; experiments in soil management in apple orchards; experiments with fertilizers in peach orchards; experiments in plum growing; studies of the adaptation of apple varieties.

Studies of Agricultural Practices and Conditions. — The college has been endeavoring for some years to secure sufficient funds to prosecute fundamental studies of the actual practices and conditions under which the farmers of the State are working. For example, a thoroughgoing study of present methods of dairy management will perhaps do as much as any other one thing to assist the dairymen to a larger success, especially if this study is combined with a careful investigation of the market conditions under which milk is sold and distributed. The milk question is perennially before us for discussion, and yet with all that has been said the most conspicuous fact is our lack of knowledge of actual conditions of production and marketing. There is no single appropriation that can be made by the Legislature that will be of larger service in settling this problem than an appropriation which will permit experts to study thoroughly the conditions which surround the business. What has been said of dairy farming applies equally to other phases of agriculture in the State. It is high time that this institution is supported by the Legislature in its desire to study all of those conditions under which the farmer must work, and to study with sufficient thoroughness to be of practical assistance to him.

Instruction.

The trustees recommend an increase in the annual appropriation for instruction from $75,000 to $95,000. Although we have added considerably to our instruction force in the last few years, that staff is still inadequate for the best results, both with respect to the subjects now being taught and with respect to the introduction of new subjects made imperative by our rapidly expanding knowledge of agriculture and the rapidly increasing calls for highly trained men. Instructors are needed in English, physical education, zoölogy, chemistry, botany, landscape gardening and agronomy. In microbiology a trained teacher and investigator is needed immediately in order to give the courses already planned. For some years we have been endeavoring to establish a department of rural engineering. This important subject has received very little attention at our hands, wholly for lack of funds. The trustees agree that it is the duty of the college to bring to the attention of the people of the State more completely than we are now enabled to do the ways by which the college can render service to all those interested in agriculture and country life; provision should be made for a man to develop publicity work. There is also a necessity for some increase in salaries. It has not been the policy of the college to increase every instructor's salary every year, but we do desire to pay salaries commensurate with the services of well-trained and efficient teachers. There is no doubt but our men as a rule are underpaid in comparison with professors in some of the liberal-arts colleges, and in comparison with men doing similar work in western agricultural colleges.

Repairs.

Last year the trustees asked for an increase of $30,000 in current annual appropriations to be divided equally in purchase of equipment and in repairs. The Legislature granted an increase of half that amount, and the trustees have decided to make that apply to equipment. The argument for a current annual appropriation for repairs still holds. In a plant inventoried approximately at $600,000, an item of $15,000 a year for general repairs is certainly not excessive. It is an annual charge that cannot be disregarded. It should be made a part of the annual appropriation.

Statement concerning Requests for Special Appropriations.

An Agricultural Building. — The main item which the trustees desire to press before the Legislature this winter as a special appropriation is one of $210,000 for an agricultural building. I cannot do better than to quote from my report of a year ago concerning the need of this building: —

> Although the college has been open to students nearly forty-five years, it has never had a building devoted specifically to agricultural teaching.
>
> Practically every agricultural college in the country finds it necessary and desirable to make such a building one of the most important on the campus.
>
> The rapid increase in our agricultural students has crowded the agricultural departments out of their old quarters. It is almost impossible to do efficient teaching under present conditions.
>
> The winter short-course students are also inadequately provided for.
>
> The proposed building will have three stories and a basement, and contain offices, classrooms, and laboratories for the departments of farm administration, agronomy, animal husbandry and agricultural engineering. It is proposed to erect a fireproof building and to equip it in harmony with the recent developments in these lines of work.

General Improvements. — The trustees ask for an appropriation of $40,000 as a special fund for general improvements, including repairs that will be necessary during the summer of 1913 and prior to the time when the item for repairs in the current annual appropriation, which it is hoped the Legislature will make, can become available. A large proportion of the items which make up the total of $40,000 have been placed in the legislative budget in former years, and, of course, the need for these improvements grows greater each year. The principal items comprise a general overhauling of south college, which is used partly as dormitory and partly as quarters for administrative departments; important extension of the water main; an addition to the young stock barn, absolutely necessary; the building of a piggery; important additions to the poultry plant; new walks; a greatly needed piece of macadam road; the construction of a much-needed bungalow for men employed regularly at the dairy barn and on the farm.

The Questions of Land and of Sewers. — There are several problems relative to the acquiring of land for horticultural and forestry purposes that have not yet been settled by the trustees for lack of adequate data. It is possible, however, that decisions may be reached in time to present a resolve to the incoming Legislature for appropriations for these purposes. The last Legislature passed an act enabling the town of Amherst to construct an outlet for its sewerage system. The act permitted the co-operation of the college, with the condition that the college should share in the expense. At this time it is not known what this share will mean in the way of appropriation, so that no specific amount is named in this report.

Other Needed Buildings. — I dislike to call attention to the fact that the trustees have this year omitted from the legislative budget important buildings that have heretofore been asked for but not granted. This omission is due not to any feeling that the need has in any way lessened, but simply to the desire to press for the agricultural building. Among so many needs for classrooms and laboratories it is difficult to choose, but the wise thing seemed to be to make it clear to the Legislature and to the people of the State that our most pressing building need is the agricultural building. The other buildings on which the trustees have estimates, and which we feel should be built as soon as possible are: —

Student dormitory,	$30,000
Addition to French hall,	35,000

THE RELATION OF THE COLLEGE TO THE ORGANIZATION OF MASSACHUSETTS AGRICULTURE AND COUNTRY LIFE.

In the president's report of one year ago there was a brief discussion of "the relationships of the college," in which mention was made of the need of co-operation with the public school system, agricultural schools, the normal schools, the State Board of Agriculture and voluntary associations. It is impossible to consider the work of the college on broad lines without constantly recurring to this question of relationships. Our work as a college is that of contributing to the solution of the rural problem in Massachusetts. There are other agencies and forces also contributing, each in its own way. There must, therefore, be a recognition of the need of working together, and consequently of understanding each other's work. There is a tendency to develop a multiplication of agencies, owing to the greatly renewed interest in the affairs of country life. Massachusetts has been conservative in this respect, but in some parts of the country there is serious overlapping and duplication of effort. The matter has become so serious that it really takes on the guise of a national question. At a recent meeting of the Association of American Agricultural Colleges and Experiment Stations a resolution on this subject was introduced. After discussion it was referred to the executive committee of the association, with instructions to study the problem thus raised and to make the general question a prominent subject for discussion at the next annual meeting. The resolution was substantially as follows: —

> *Whereas,* The various agencies for agricultural education in America are multiplying with great rapidity, and
>
> *Whereas,* We believe that there is danger of serious loss of energy and increase of expense, on account of overlapping on the part of these agencies as they carry on their work; therefore
>
> *Resolved,* That this association advocate the appointment of a National Commission on Agricultural Education (preferably a permanent commission), which shall be charged with the duty of inquiring into, and reporting upon, the organization and policy that, in the opinion of the commission, should prevail in the expenditure of public moneys provided for the United States Department of Agriculture, for State boards, or departments, of agriculture, for land-grant colleges, for secondary schools of agriculture, or for any other institution for agricultural research, teaching or extension, to the end that such funds may be applied in the most economical, efficient and worthy manner to the production of results of permanent value. It will be especially incumbent upon the commission to indicate and advise concerning the fundamental functions of these various institutions in the upbuilding of American agriculture and country life, and their relationships one to the other, so that there may be a minimum of overlapping, and, on the positive side, a constructive policy of definite co-operation. Such a commission might also well become the advisory board with respect to the use of private funds for these same purposes.

In connection with the discussion of this resolution it was suggested that each State should move toward the organization of a commission on agricultural education, or of some similar body, charged with the duty of ascertaining how the various agricultural forces in each State may be co-ordinated.

Because of the fact that this general subject of bringing together in some co-operative way the efforts of various agencies and institutions interested in agriculture and country life has become a national question in the realm of agricultural college discussion; and inasmuch as in Massachusetts there are already evidences of a need of a clearer understanding of the situation; and also because this college cannot do its best work except by maintaining proper relationships to other organizations, I have thought it timely to discuss at some length the problem thus raised, under the title, "The Relation of the College to the Organization of Massachusetts Agriculture and Country Life."

The Outlook for Agriculture in this State.

The outlook for the agricultural business in Massachusetts was never so promising as at the present day. An examination of the appended tables shows a really remarkable development in the agriculture of the State, in spite of the smaller acreage of improved land. It is true that values are influenced by the general rise of prices; nevertheless, farming is prosperous as compared with the situation thirty years ago, or even ten years ago.

These figures also mean a rapidly growing market, particularly for products grown not too far from the consumer. Prices rule high as compared with other parts of the country.

There is also a new interest in agriculture on the part of the farmers themselves, on the part of business men and on the part of residents of the cities. All these things give us courage to believe that we are at the beginning of a great revival of the agricultural industry in Massachusetts, and, indeed, in all New England.

Agricultural Statistics of Massachusetts (*United States Census*).

	1880.	1890.	1900.	1910.
Acreage of land in Massachusetts: —				
(*a*) Land in farms,	3,359,079	2,998,282	3,147,064	2,875,941
(*b*) Improved land,	2,128,311	1,657,024	1,292,132	1,164,501
(*c*) Unimproved land,	1,230,768	1,341,258	1,854,932	1,711,440
Value of agricultural products,	$24,160,881	$28,072,500	$42,298,274	$59,901,277
Value of product per acre of improved land,	$11 33	$16 94	$32 73	$51 44
Rural population,	866,071	736,890	919,541	1,103,248
The population of incorporated cities,	917,014	1,579,234	1,809,644	2,263,168

THE AGRICULTURAL ADVANTAGES WHICH MASSACHUSETTS OFFERS.

We may be compelled to admit that Massachusetts can hardly become one of the leading agricultural States quantitatively. As compared with Iowa and Illinois, for example, Massachusetts cannot hope to figure prominently in farm statistics, although its possibilities in value of agricultural products are far greater than many of us imagine. But there is every reason why Massachusetts can hope to become, and ought to become, a really great agricultural State qualitatively. It is a small State. It has a fairly compact area. It has many varieties of soil and differences of altitude. It has markets among the best in the world. It has great wealth, public spirit, abundant social machinery. It is a land beautiful to look upon. It possesses splendid traditions of education. It has been a leader in the industrial, political and social life of the nation, and it still retains a large measure of that leadership. Those who work its land are largely owners of the land, and at the present time most of them are the old New England stock. Its cities and larger villages are numerous, and, as a rule, they are connected with other places by trolley lines. There are few regions of the State that are necessarily isolated.

All these things comprise the natural resources and the foundation for an ideal agriculture and country life. We ought to make the best possible use of these splendid resources, not only for profit but for securing the highest type of rural life. If we aim to make "Bay State quality" a real asset in our farm production and in the development of rural communities that are here built up, we may soon take our stand proudly as a Commonwealth containing the best type of agriculture and country life in all the world. We are already doing much to justify the claim of high quality, but our desire should be nothing short of the highest. We need a great public ambition on behalf of Massachusetts agriculture and country life, a thoroughly progressive spirit on the part of the farmers, combined with a willingness to co-operate among themselves and with other people.

PROGRESSIVE AGENCIES.

A catalogue of the efforts that are now being made to improve Massachusetts agriculture and country life shows that our people are not unmindful of their opportunities.

The State Board of Agriculture has supervision of 32 agricultural fairs to which it pays bounties. It held during the past year 138 farmers' institutes. It publishes an annual report, monthly crop reports, bulletins, nature leaflets and reports of other phases of its work. The work of the Dairy Bureau of the State Board of Agriculture consists in police work relative to the enforcement of dairy laws and educational work for the purpose of improving dairy products. The Board also is responsible for nursery inspection and apiary inspection, employs an ornithologist, and encourages agriculture directly by special exhibits, demonstrations and the distribution of bounties to incorporated poultry associations.

The State department of animal husbandry enforces laws relative to contagious diseases of domestic animals, and has also the power to secure proper hygienic conditions for such animals.

The forest service of the State carries on an elaborate forest-fire protection, develops reforestation, and has charge of the suppression of the gypsy and brown-tail moths. It promotes the perpetuation, the extension and the proper management of the forest lands of the Commonwealth, both public and private. On request it gives owners of forest land aid and advice in the management thereof.

The grange in Massachusetts has a membership of 32,000, with about 230 subordinate granges, in nearly as many towns of the State. It is growing and is reaching out to perform new tasks for the rural population.

The fruit and corn shows that are held from time to time are demonstrating the possibilities of both of these industries in Massachusetts, as well as illustrating better methods, and calling together people to observe what is actually being achieved.

Various chambers of commerce in the cities of the State are interesting themselves in the agricultural problems of the Commonwealth. The Boston Chamber of Commerce, the most powerful commercial body in New England, has a committee on agriculture. The Springfield Board of Trade has been notably active in co-operating with agricultural agencies. The Worcester Board of Trade has taken an interest in agricultural propaganda in that county.

The New England railways have established an industrial bureau, which interests itself in the development of agriculture as well as in that of manufacturing. Both the steam and electric railways have lent their aid in various educational enterprises on behalf of agriculture.

We have in Massachusetts a federation of churches organized on the broadest possible basis, officered by clear-visioned prophets of a better religious life. Special attention is being given to the country church, its needs and its possibilities of leadership in the building of a better rural Commonwealth.

The Massachusetts State Library Association, although existing in a State that has more public libraries than probably any other State in the Union, nevertheless has constructive plans for a wider distribution of books in the more sparsely settled communities.

The State Board of Education is carrying on a comprehensive campaign on behalf of a thoroughgoing system of agricultural education of high school grade.

Agricultural newspapers have a wide circulation in Massachusetts and are full of optimism with respect to the future of Massachusetts and country life.

The Young Men's Christian Association has an active rural work.

The Massachusetts Experiment Station is rendering a great service in various lines of control work in the testing of commercial fertilizers, of stock foods, and of dairy-testing apparatus. The experiment station also, as an organ of research, has been for years carrying on fundamental investigations with respect to the best use of Massachusetts soils and the best crops to grow on these soils.

The Massachusetts Agricultural College has over 500 students of college grade, preparing for leadership in the various agricultural vocations. It also has each year nearly 300 students taking shorter courses in agriculture.

The Extension Service of the Agricultural College is giving correspondence courses to several hundred regular readers, lecture courses and demonstrations in various parts of the State, local and State conferences for rural community development, extension schools of agriculture, educational trains, educational exhibits and demonstrations at fairs, demonstration orchards, and it is organizing dairy and agricultural improvement associations, making agricultural surveys, organizing girls' and boys' agricultural clubs, and answering tens of thousands of letters each year.

This mere cataloguing of enterprises carried on in this Commonwealth on behalf of agriculture and country life shows the enormous amount of time and energy and money which is being expended to-day, and being expended in faith of a harvest of better crops, of greater profits and of a sweeter, finer individual and community life in the rural towns of the State.

Some Dangers in the Situation.

All this activity is good. It indicates that Massachusetts has developed the machinery by which agricultural progress may be forwarded. But there are dangers in this very fact of multiplication of effort. May I suggest two or three that seem to lie on the surface?

1. The danger of *duplication*. The more aggressive an organization or institution, the greater the danger of doing work that is being attempted, or should be attempted, by some other organization or agency. Thus money may be wasted.

2. The danger of *working at cross purposes*. There is likelihood that different ends may be pursued by the different institutions, that various agencies may plow the same field at different angles, thus nullifying the work of one another.

3. The danger of *omission*. Important things may be left undone. Institutions as well as individuals are inclined to want to do the things that are suggested by what somebody else has done.

In other words, the danger of overlapping of these various efforts may become serious and may work against the best development of our agriculture and country life.

The Advantages of a Comprehensive Plan for advancing Agriculture and Country Life.

The considerations just mentioned are in my judgment sufficient to raise the question whether we should not at once take steps to prevent duplication and overlapping. In other words, may we not, through the development of a comprehensive plan for the upbuilding of agriculture and country life in the whole Commonwealth, not only avoid overlapping of effort, but may we not also, by setting forth an ideal, thereby advance in manifold ways and by many years the realization of our watchword, "Bay State quality"? Some of the advantages of such a comprehensive plan seem to be fairly obvious, as, for example: —

1. It would tend to prevent duplication of work and save unnecessary time and money.
2. It would give a working ideal toward which every one could strive.
3. It would assist in getting the large and important things done.
4. It would aid in securing the co-operation of all the agencies, institutions and individuals that are interested in a better agriculture and country life.

AN IDEAL PROGRAM FOR MASSACHUSETTS AGRICULTURE AND COUNTRY LIFE.

I am perfectly aware that an attempt to state an ideal program for such a large movement as the development of the agriculture and country life of a State might bring upon us the criticism of practical men as well as the criticism of the theorists. Practical men are sometimes inclined to scoff at a plan that seems to be visionary, and that involves a long period for its realization, even in part. The theorists will never agree on a program. Nevertheless, I venture to suggest such a program, largely for the purpose of indicating the value of a definite plan of some sort as a basis for a comprehensive organization of agriculture and country life. We must look at the problem in the largest possible way. So far as practicable we must look at the problem as a unit, — the rural problem in Massachusetts. I suggest, therefore, the following ideal program: —

In general, we need —

1. To create enthusiasm for an enlarged Massachusetts agriculture; for an enriched Massachusetts country life.
2. To encourage every needed association and institution which is working for rural betterment and agricultural advancement in Massachusetts, and to assist each to gain definiteness, directness and efficiency for its particular task.

3. To secure the co-operation of all the agricultural interests of Massachusetts on behalf of a concerted plan for a better agriculture and country life in every rural town of the State.

4. To gain for this co-operative movement among agricultural agencies the active support of the commercial and industrial interests of Massachusetts.

5. To develop adequate publicity for Massachusetts agricultural possibilities.

6. To educate consumers as to Massachusetts-grown products of the soil, — their quality, value, and use; and in other ways to extend the market for Massachusetts agricultural products.

In particular, we need —

1. To secure an adequate inventory of Massachusetts agricultural resources.

2. To devise and carry out educational campaigns for the most efficient agricultural practice and farm management, — for the best use of every acre of Massachusetts soil, while conserving soil resources.

3. To improve the methods of marketing farm products, in order that all consumers may have a wider range of choice Massachusetts-grown products at a fair price, and that the producers may have a reasonable profit for intelligent labor.

4. To secure legislation that shall protect both producers and consumers, with justice to both, and that shall stimulate and encourage the agricultural workers.

5. To secure better highways and other means of communication in the rural regions of Massachusetts.

6. To improve the rural schools, and to build a comprehensive public system of agricultural education both for youth and for adults.

7. To conserve and develop the beauty of rural Massachusetts.

8. To increase the means of wholesome recreation for young and old in the rural communities of Massachusetts.

9. To encourage the church and its allies to renewed labor and more efficient service in all rural towns.

10. To encourage every wise endeavor for the preservation of the Massachusetts rural home, the lightening of its labors, and the widening of its influence in the community as well as upon the lives of its members.

Some such general, or ideal, platform is needed in order to give scope and breadth to the attempt to organize the rural interests of the Commonwealth. But we also need —

A Working Program of Large Rural Enterprises needing Immediate Attention.

1. *Secure the Best Use of Present Cultivated Areas.* — This implies a series of well-developed educational campaigns for stimulating farmers to follow the most approved methods. An example at hand is the attempt to secure the general use of high-grade seed-corn. Our ambition should be to make every cultivated acre in Massachusetts yield the largest possible profit.

2. *Develop the Waste and Unimproved Areas.* — There are tens of thousands of acres of waste lands, both along the coast and in river valleys, that are at present unavailable for agricultural purposes, but that when once drained might become the richest of our soils. The development of these lands must be preceded by a scientific study of their availability and a comprehensive plan for their drainage and use. Much of the land now listed as unimproved undoubtedly has uses if we could but find them.

3. *Help the Farmers to secure an Adequate Farm Labor Supply.* — This is one of the most difficult and perhaps the most important of our agricultural problems in Massachusetts. Its importance, however, rather than its difficulty should be the warrant for making it the subject of careful study and for devising methods for meeting the conditions that exist.

4. *Establish a Better System of Rural Credit.* — We are not yet sufficiently in possession of facts to be able to say just to what degree our Massachusetts farmers are lacking in facilities for securing both permanent and working capital. It is safe to say, however, that the time is soon coming, if it has not already arrived, when the need for better credit facilities will be a pressing need among our smaller landowners.

5. *Devise a More Efficient System of Marketing.* — The discrepancy between the prices paid by the consumer of farm products and the prices paid to the producer is a subject of constant comment and dissatisfaction to both parties concerned. We should attempt to organize, as soon as practicable, a system of

distribution of agricultural products which will secure prices less fluctuating than now, and such that the farmer may receive a fair profit. In other words, the wastes and excessive costs of the present system of distribution must be minimized.

6. *Perfect the System of Agricultural Education.* — A complete system of agricultural education will include the teaching of agriculture not only to college students, but also to boys and girls of high school age and to adults and young people who are not attending school. Massachusetts is well on the way toward a well-developed system. However, we must see to it that this system is based on sound principles, and that its parts work together in complete harmony.

7. *Get and keep the Right Kind of People on the Land.* — It is difficult to influence in any marked way, by agitation or by legislation, or even by education, the currents of human migration as they flow from the country to the city, or from the city to the country, or from one nation to another. But it is clear that in New England we face a very serious question with respect to the maintenance of the quality of people living on and working the New England soil. It is often claimed that this quality has appreciably deteriorated in the last century. However that may be, we know perfectly well that in many parts of New England the land is being occupied by people of different ideals and standards of living than we have been accustomed to. The question is, can we insure a high quality of immigration to our lands, either from the city or from other countries or from the west; and once these people are on the land can we insure a scheme of education that shall rapidly bring them into sympathy with, and understanding of, our best American life? Certainly we should not decline to exercise every effort to maintain the sort of rural population that we desire.

Complete Organization of Agriculture and Country Life.

It is my firm conviction that we need a complete organization of agriculture and country life in order to bring about such desirable advancements as have been described. We must secure a measurable degree of co-operation among all the factors that make for better conditions. It is perfectly true that we *can* work in piecemeal fashion, but that is not the spirit of the age and it is not the best method. Neither the State nor any group of individuals nor any organization can dictate the methods of progress or the way in which co-operation may be secured. But we can secure such an organization of all the agricultural and country life interests in the Commonwealth that they shall work together intelligently and sympathetically on behalf of the larger interests of our rural people, and thus on behalf of the welfare of the entire Commonwealth.

THE METHOD OF ORGANIZATION.

In considering a method by which this large and complete organization of agriculture and rural life interests in Massachusetts may be achieved, the main reliance must be placed on the idea of *federation* of interests. We do not need a new organization. We simply need a getting together of existing organizations and agencies. In other words, the federal, or representative, idea is the key to the situation.

A PLEA FOR A MASSACHUSETTS FEDERATION FOR RURAL PROGRESS.

Therefore I would recommend that the trustees authorize a call, as soon as such a step seems wise — perhaps next autumn — to the representatives of all the various interests that have been catalogued, and such others as are interested, for the purpose of discovering whether the time is not ripe for a definite federation of these interests on behalf of an enthusiastic, clear-cut, well-planned, persistent effort to bring Massachusetts agriculture and country life to its highest possible development. This movement is already under way in some of the towns of the State and, indeed, in the State as a whole, but it needs organizing.

We cannot of course state the exact form that such a movement may take. A number of towns in the State have already appointed town committees or developed town federations for rural improvement. Clearly, we must have each town seeking to make the best use of its resources before we can have the State as a whole making the best use of its resources. The heart of the movement is the attempt of each town to study its own resources and its needs, and to map out a plan for bettering conditions in the town. It has already been suggested that these town rural life "committees" (or "councils" or "federations") co-operate in a county organization of a similar type; and, finally, that representatives of these county organizations unite with the representatives of the various State-wide organizations and agencies in a Massachusetts federation for rural progress.

THE RELATION OF THE STATE TO THE CAMPAIGN FOR RURAL PROGRESS.

It is obvious, also, that the State of Massachusetts itself, not only through legislation but through various institutions and agencies supported out of the State treasury, can and must continue to render a great service in this renewed effort to secure the best quality of agriculture and country life for the Commonwealth. This is one of the most significant aspects of our attempt to bring about a thorough organization of Massachusetts agriculture and country life. The State cannot achieve all that needs to be done working apart from private individuals and voluntary organizations, but it can and should play a vital part in the general plan.

WHAT THE STATE SHOULD DO.

The State should —

1. Gather facts.
2. Protect.
3. Stimulate.
4. Develop.
5. Educate.
6. Provide a clearing-house for agricultural and rural life interests.

1. *The State should gather Facts.* — We need to know our agricultural resources and possibilities. We need to know existing agricultural methods. We need to know the tendencies and needs of the markets both at home and abroad.

There are two classes of facts that need gathering. The first class comprises a census of those facts that have a bearing upon the agricultural business and method. They should be gathered every year. They have to do with production, with prices, with miscellaneous agricultural statistics. The other class may be designated more completely by the word "investigation." There must be a constant study of fundamental problems of the soil and of plant and animal growth, as well as a study of those economic and social conditions that have so much influence in the farmer's work and life.

2. *The State should protect.* — It should protect the farmers against diseases and pests, against fraud and injustice. It should protect the better and honest farmers against the inferior and dishonest farmers. This protection will be secured through proper legislation enforced by appropriate executive boards or commissions.

3. *The State should stimulate.* — It should to some degree offer prizes. It should have general supervision of the agricultural-fair system. It should advertise the agricultural advantages of the State to its own people, to the people of other parts of the land, and to the people of those foreign countries that are able to contribute a stalwart and acceptable rural population to our Massachusetts farms.

4. *The State should develop.* — Without question full sweep should be given to individual initiative. At the same time, there are problems to solve so complicated, so difficult, so far-reaching that it will be almost impossible to work them out unless the State in some way lends direct aid. For example, to recur to a matter already mentioned, we have in Massachusetts tens of thousands of acres of waste land. Some of these lands are near tidewater. They can be drained only under some large scheme. Other thousands of acres of these lands are in the valleys and along streams, perhaps overflowed by waters that were once useful for manufacturing purposes, but that are no longer useful. Other thousands of acres are rough land; some of them available only for forestry purposes, but a very large proportion of them capable of development for prosperous sheep-growing or orcharding. It is only through some form of State aid and leadership that these waste lands can be developed. They are an unworked asset. They ought to be developed as soon as possible, on some comprehensive plan. They should, first of all, be surveyed and their possibilities understood.

So, also, in the development of adequate credit facilities and market facilities, the State should render necessary assistance, even though the actual business organization is co-operative among individuals or organizations.

The State can continue to assist prospective purchasers of farms in locating those farms and in furnishing information concerning the best uses to which those farms can be put.

The State can assist in securing an adequate labor supply by acting as a clearing-house for labor engagements and, what is more important, by securing from foreign countries or from the cities an adequate number of skilled laborers. The same thing is true to a large degree in the development of an adequate system of marketing of farm products.

If all Massachusetts acres are to be tilled to their full capacity, it means a larger rural population. There is a tide setting in from the city toward the country, and undoubtedly during the next ten years a great many people will come out from the cities to take farm lands and work them permanently. There is undoubtedly a considerable number of farmers in the middle west — many of them of New England descent — who for one reason or another would like to get back to New England. Some of them like the New England life; some wish to engage in certain specialties that can be developed in the east better than in the west; some would like to sell their relatively high-priced lands and buy the cheaper lands of New England. The State, through an organized effort, could encourage these people to locate advantageously in Massachusetts. It is also a matter of concern as to the type of immigrant that comes from foreign shores to settle our lands, whether he has the capacity to develop in modern agriculture, and whether he will assimilate with our American institutions. The State should see to it that efforts are made to get the right sort of people on the land.

5. *The State should educate for Agriculture.* — It should have a comprehensive system of investigation, of teaching and of extension service at the agricultural college. It should have a well-developed system of agricultural departments in our high schools and in the special agricultural high schools. So far as consistent with good educational principles, agriculture should be brought to the attention of pupils in the upper grades of the public schools.

6. To some degree, at least, *the State should provide a clearing-house for the organization of agriculture and country life.* In other words, the State itself should co-operate most intimately and cordially with a State federation for rural progress in the development of a comprehensive campaign for a better agriculture and rural life.

THE PRINCIPLES UNDER WHICH THE STATE SHOULD MAKE ITS CONTRIBUTION TO THE ORGANIZATION OF AGRICULTURE AND COUNTRY LIFE.

If the State is to participate, as it should, in this effort to bring agriculture and country life in Massachusetts to its highest levels, there are a few fundamental principles that must be invoked.

1. *The Principle of Local Initiative.* — There should be a maximum of effort on the part of individuals and voluntary organizations. It is not the business of the State to do either for individuals or for towns what they can do for themselves. The State, therefore, should encourage individual and community initiative and discourage individual and community dependence upon outside agencies.

2. *The Principle of Co-operation.* — This principle is recognized in all our business and social life and cannot be disregarded however much we may cherish the old individualism of the past. As a matter of fact, there is little danger that this individualism, in New England at least, is likely to be crowded out. We need, rather, to encourage the spirit of working together. This principle of co-operation also means an institutional division of labor, that is, making sure that the different organizations and agencies do their own particular kinds of work, and then that all co-operate for the one large, common end.

3. *The Principle of Federation.* — It is desirable to centralize our efforts, but not to centralize authority or power. Consequently, the federal principle forms the best method for securing co-operation of individuals and institutions.

THE MAIN AGENCIES OF STATE AID FOR AGRICULTURE.

There are two main agencies by which the State can develop its proper relationship to the organization of agriculture and country life. The first is the State Board of Agriculture; the second is the Agricultural College. This statement is not meant to convey the idea that these are the only agencies by which the State can develop its activities on behalf of agriculture and country life, but in these two center the main lines of effort in which the State should participate. They are characteristic, specialized agencies of the State. Among those miscellaneous agencies, whose function is not, however, specifically rural, are the State Board of Education, the State Board of Health, the Railway Commission, the Highway Commission, etc. All of these boards have functions that bring them into close touch with the development of a better country life. But their prime function is connected with the people as a whole and not with the rural problem specifically. They must be considered in any attempt to relate the State to a campaign for rural progress.

It would be unwise to prolong this discussion by treating exhaustively all the respective functions of these two main agencies, but it is absolutely necessary to outline in a terse way the special tasks that I believe should be developed by them. It must be remembered that these tasks will, in some degree, overlap, and that the co-operative spirit and method must be constantly used as the work is developed.

The Function of the Board of Agriculture.

The function of a well-organized board of agriculture in an American State is not primarily educational but administrative. Among the various types of work which should be fostered and controlled by such a board are the following: —

1. The gathering of current statistical facts, especially concerning business tendencies and needs.
2. The administration of laws designed to protect the farmers.
3. The administration of those enterprises designed to stimulate and foster agriculture.
4. The administration of those efforts that have to do with the development of agriculture, in so far as the State wishes to participate in such efforts.

In these matters the board of agriculture should take the initiative. The college may help at many points.

The Function of the Agricultural College.

The American agricultural college has as its mission education and not administration. This education divides itself very naturally into three main lines of effort.

1. Investigation, which includes not only the study of the laws of nature with respect to the soil and the growth of plants and

animals, but also an investigation of actual conditions — physical, economic, social — under which farmers work and live.

2. The education of men and women who shall be rural-problem solvers. This is accomplished through regular and special courses offered at the institution.

3. The educational function also embraces the extension service, which attempts to reach those who cannot come to the college, with the best of information concerning all phases of the rural problem.

The college, also through its extension service, should serve as a clearing-house for the general movement to organize agriculture and country life in the Commonwealth. It should co-operate heartily with the federation for rural progress, and should be in close touch with the varied efforts of the board of agriculture.

In all these matters the college should take the initiative, although at many points the board of agriculture may assist.

The Function of Local Government.

In all this work there might well be a larger participation of local government, both of counties and towns, on behalf of a better agriculture and country life. We do not yet know by what means this larger participation may be developed, but I believe that we must rely more fully than we have ever done before on the local civic groups for practical assistance in working out our country life problems.

The Next Step.

It is obvious that the main ideas here advanced can be realized only by some definite co-operative action on the part of the institutions and organizations most intimately connected with the development of Massachusetts agriculture and country life. It is of first importance to determine the scope of State aid to agriculture, the function of the board of agriculture, of the Agricultural College, and of other State agencies in this scheme of State aid, and the relationship of these one to another and to all of the voluntary organizations and enterprises interested.

A COMMISSION ON AGRICULTURAL EDUCATION AND ORGANIZATION.

I therefore believe the time has come for the organization of a commission to study and report on the question of the relationship of the State to rural development in Massachusetts. I suggest a commission of seven appointed as follows: one by the State Board of Agriculture; one by the executive committee of the State grange; one by the Board of Trustees of the Massachusetts Agricultural College; one by the State Board of Education; and three by the Governor. One of those appointed by the Governor should be a practical farmer, and one should be an attorney of recognized standing.

The appointment should be for a period ending on the presentation of the report of the commission at a date not later than Jan. 1, 1915.

The members of the commission should serve without pay, but necessary expenses should be paid, and authority should be granted, under the approval of the Governor and Council, to travel in other States and, if necessary, to send member or agent delegate to Europe for the purpose of learning what is being done in other States and countries. The commission should be authorized to employ a secretary at a salary not to exceed $150 a month, should be given sufficient clerical help and should be required to present a report not later than Jan. 1, 1915. There should be an appropriation ample to carry on the work of the commission.

The special duties of the commission should be as follows: —

1. To collect all the laws of the Commonwealth bearing on agriculture and country life, and to recommend a code or group of acts designed to cover the present needs of the Commonwealth, in so far as legislation may be considered effective and desirable in the proper control and development of the agricultural industries and rural affairs in the State.

2. To report on the best methods of aiding agriculture, and the best form of organization for such State boards and institutions as are needed.

3. To present a statement relative to the best methods of coordinating the activities of the various agencies in the Common-

wealth, both public and private, which are designed to benefit agriculture and country life, and the relation of the Commonwealth thereto.

If this suggestion for a commission appointed by the Legislature seems too formidable, or is considered impracticable at the present time, it is possible that progress could be made if some one of the institutions interested should take the initiative in calling together a voluntary conference to be made up of a representative or representatives of several of the agencies interested, for the purpose of discussing the questions raised in this report.[1]

Respectfully submitted,

KENYON L. BUTTERFIELD,
President.

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[1] The above report was accepted by the trustees of the college, and a vote passed to the effect that the trustees favor the idea of a conference of representatives of State and other agencies interested in agriculture and country life, and that they recommend that each of the following organizations appoint a representative or representatives to such a conference for the purpose of conferring on the suggestions contained in the report: The State Board of Agriculture, The State Board of Education, The Massachusetts State Grange, The Massachusetts Society for the Promotion of Agriculture, The Boston Chamber of Commerce, The Massachusetts Agricultural College.

At the annual meeting of the State Board of Agriculture, held Jan. 7 and 8, 1913, it was voted to join in the suggestion made in the above report, and the secretary of the board of agriculture was authorized to invite the above-named organizations to elect representatives to the conference.

STATISTICS OF THE COLLEGE.

TABLE I. — *Attendance.*

	Registration Nov. 30, 1911.	Registration Nov. 30, 1912.
Senior class,	85	91
Junior class,	97	102
Sophomore class,	127	125
Freshman class,	168	184
	477	502
Graduate students,	15	22
Unclassified students,	29	31
Total doing work of college grade,	521	555
Short courses: —		
Winter school,	113	131
Poultry course,	74	80
Apple-packing school,	–	40
Beekeepers' course,	16	10
Summer school,	153	–
	356	261
Total,	877	816

TABLE II. — *Legislative Budget, 1912.*

ITEMS.	Amount asked.	Amount granted.
1. Special appropriations: —		
Agricultural laboratory and equipment,	$200,000 00	–
Student dormitory,	25,000 00	–
Addition to French Hall,	25,000 00	–
Addition to Draper Hall,	25,000 00	$25,000 00
Dwelling for registrar,	8,000 00	–
Tenement house for farm help,	6,000 00	–
Sewers,	10,000 00	10,000 00
Department equipment,	31,525 00	20,000 00
Repairs and minor improvements,	20,760 00	15,000 00
General improvements,	35,135 00	10,000 00
	$386,420 00	$80,000 00
2. Increase in current annual appropriations: —		
Administration,	$5,000 00	$5,000 00
Maintenance and equipment,	37,000 00	22,000 00
Investigation,	14,000 00	4,500 00
Instruction,	23,000 00	15,000 00
Short courses and extension,	30,000 00	30,000 00
	$109,000 00	$76,500 00
Previous appropriation,	173,500 00	173,500 00
Total,	$282,500 00	$250,000 00

TABLE III. — *Statistics of the Extension Service for 1912.*

Extension Service conducted at the College.

Farmers' week,	1,040
Polish farmers' day,	57
Conference for rural community leaders,	184
Correspondence courses: —	
Present enrollment,	578
Courses completed or work dropped during year,	175
Number of people reached through short courses and correspondence courses,	2,034

Extension Service conducted away from the College.

Lectures:[1] —	
Number given in 1912,	591
Approximate attendance,	27,469
Fairs: —	
No exhibits made, but members of the faculty acted as judges and gave lectures at 16 fairs throughout the State. No attendance was taken.	
Demonstration orchards: —	
Requests on file,	34
New orchards planted,	2
Renovation plots,	1
Boys' and girls' corn and potato clubs: —	
Number of clubs,	127
Number enrolled,	13,462
Massachusetts Agricultural College Agricultural Improvement Association: —	
Membership,	137
Dairy Improvement Association: —	
Number organized,	3
Number of members,	55
Extension schools: —	
Requests for schools,	16
Schools given,	5
Membership,	351
Enrollment,	500
Judging contests,	13
Enrollment,	111
Traveling libraries: —	
Public libraries receiving books,	36
High schools,	1
Volumes sent out,	629
Bulletins, pamphlets, etc.,	252
Average size of shipment,	24
Farm visits: —	
Visits made,	66
Student extension work: —	
Evening schools held,	4
Teachers,	9
Average attendance each week,	80
Mailing list: —	
Facts for farmers,	1,553
Short courses,	3,764
Total number of people reached,	49,231

These numbers do not include the attendance of the various meetings held at the college by organizations throughout the State.

TABLE IV. — *Public Speakers for the Year.*

A. *Speakers at Sunday Chapel for Year ending Nov. 30, 1912.*

1911.

Dec. 10. — Dr. Samuel A. Eliot, Boston.

1912.

Jan. 7. — Mr. Robert E. Speer, New York City.
Jan. 14. — Rev. J. S. Lyon, Holyoke.
Jan. 21. — Mr. Henry Bond, Brattleboro, Vt.

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[1] This is not accurate, as many lectures are not reported.

1912.
Jan. 28. — Rev. F. Boyd Edwards, Orange, N. J.
Feb. 11. — Dr. Albert P. Fitch, Cambridge.
Feb. 18. — Dr. Herbert J. White, Hartford, Conn.
Feb. 25. — Mr. W. R. Moody, Northfield.
Mar. 3. — Rev. J. W. Campbell, Newtonville.
Mar. 10. — Rev. Lee W. Beattie, New York City.
Mar. 17. — Mr. Ray Stannard Baker, Amherst.
Mar. 24. — Mr. Herbert S. Carruth, Amherst.
Apr. 14. — Rev. Robert A. Ashworth, Milwaukee, Wis.
Apr. 21. — Col. E. W. Halford, New York City.
May 5. — Mr. Jacob Riis, New York City.
Nov. 3. — Rev. Clarence F. Swift, Fall River.
Nov. 10. — Bishop Thomas F. Davies, Springfield.
Nov. 17. — Mr. Alfred H. Evans, Northampton.
Nov. 24. — Rev. Paul Van Dyke, Princeton, N. J.

B. Speakers at Wednesday Assemblies for Year ending Nov. 30, 1912.

1911.
Dec. 13. — Mr. John Nolen, Cambridge.

1912.
Jan. 10. — Prof. William D. Hurd, Massachusetts Agricultural College.
Jan. 17. — Dr. J. H. McCurdy, Springfield.
Jan. 24. — Rev. George M. Rowland, Auburndale.
Feb. 7. — President Kenyon L. Butterfield, Massachusetts Agricultural College.
Feb. 14. — Miss Ida M. Tarbell, New York City.
Feb. 21. — Mr. Henry Sterling, Boston.
Feb. 28. — Mr. W. M. Danner, Boston.
Mar. 13. — Pres. Harry A. Garfield, Williams College.
Mar. 20. — Mr. J. W. Pincus, New York City.
Mar. 27. — Mr. William Jessup Sholar, Boston.
Apr. 10. — Hon. Michael J. Murray, Boston.
Apr. 17. — Prof. Edgar L. Ashley, Massachusetts Agricultural College.
Apr. 24. — Pres. Frederick W. Hamilton, Tufts College.
May 1. — Mr. J. G. Phelps Stokes, New York City.
May 8. — Pres. Kenyon L. Butterfield, Massachusetts Agricultural College.
May 15. — Rev. A. Z. Conrad, Boston.
June 5. — Pres. Kenyon L. Butterfield, Massachusetts Agricultural College.
Sept. 18. — Pres. Kenyon L. Butterfield, Massachusetts Agricultural College.
Sept. 25. — Hon. James Logan, Worcester.
Oct. 9. — Associate Dean Edward M. Lewis, Massachusetts Agricultural College.

1912.
Oct. 23. — Prof. Charles E. Marshall, Massachusetts Agricultural College.
Nov. 6. — Hon. James J. Storrow, Boston.
Nov. 13. — Prof. Robert J. Sprague, Massachusetts Agricultural College.
Nov. 20. — Mr. William Chauncy Langdon, New York City.

TABLE V. — *Statistics of Freshmen entering Massachusetts Agricultural College, September, 1912.*

A. Home Addresses of Students (classified by Towns and Cities).

Acushnet,	1	Hopedale,	1	Quincy,	1
Adams,	2	Jamaica Plain,	2	Rockville,	1
Amherst,	4	Jefferson,	1	Roslindale,	1
Apaupo, N. J.,	1	Kingston,	1	Roxbury,	1
Arlington,	1	Lawrence,	5	Roxbury Station, Conn.,	1
Ashfield,	1	Leominster,	3	Royalston,	1
Auburndale,	1	Longmeadow,	1	Rowe,	1
Beverly,	1	Lowell,	2	Saxonville,	1
Boston,	5	Lynn,	1	Sayville, L. I., N. Y.,	1
Bridgewater,	1	Malden,	4	Seymour, Conn.,	1
Brockton,	1	Manchester,	1	Shelburne Falls,	1
Brookline,	1	Mansfield,	1	Somerset,	1
Brooklyn, N. Y.,	3	Marlborough,	1	Somerville,	4
Canton,	1	Mattapan,	1	Southborough,	1
Centreville, R. I.,	1	Melrose,	4	South Duxbury,	1
Clinton,	1	Melrose Highlands,	3	South Hadley,	1
Concord,	1	Mendon,	1	South Hadley Falls,	1
Cranford, N. J.,	1	Merrick,	1	South Harwich,	1
Dalton,	2	Merrimac,	1	South Natick,	1
Dalton, Pa.,	1	Milford,	1	South Weymouth,	1
Dedham,	2	Millbury,	1	Springfield,	3
Deerfield,	1	Millers Falls,	1	Stockbridge,	1
Dorchester,	3	Millis,	1	Stoughton,	1
Doylstown, Pa.,	1	Montague,	2	Sunderland,	2
East Dover, Vt.,	1	Mount Vernon, N. Y.,	1	Taunton,	1
Easthampton,	1	Natick,	2	Ticonderoga, N. Y.,	1
Exeter, N. H.,	1	Newbury, Vt.,	1	Turners Falls,	3
Fall River,	1	Newtown, Conn.,	1	Vineyard Haven,	1
Fitchburg,	1	North Abington,	1	Waitsfield, Vt.,	1
Flemington, N. J.,	1	North Adams,	1	Waltham,	2
Florida, N. Y.,	1	North Amherst,	3	Warren,	1
Forest Hills,	1	Northampton,	1	Westford,	2
Foxcroft, Me.,	1	Northborough,	1	Westminster,	1
Framingham,	3	North Brookfield,	1	West Springfield,	2
Georgetown,	1	Northfield,	1	Williamsburg,	1
Great Barrington,	1	North Middleborough,	1	Wilton, Conn.,	1
Groton,	1	Orange,	1	Windsor, Conn.,	1
Groveland,	1	Pawtucket, R. I.,	1	Winter Hill,	1
Hadley,	2	Philadelphia, Pa.,	1	Winthrop,	2
Harvard,	1	Phœnix Mills, N. Y.,	1	Worcester,	7
Haverhill,	3	Pittsfield,	2		
Hingham,	2	Plymouth,	2		

B. Home Addresses (classified by States).

	Number.	Per Cent.		Number.	Per Cent.
Connecticut,	5	2.72	Pennsylvania,	3	1.63
Maine,	1	.54	Rhode Island,	2	1.09
Massachusetts,	158	85.87	Vermont,	3	1.63
New Hampshire,	1	.54			
New Jersey,	3	1.63		184	100.00
New York,	8	4.35			

C. *Home Addresses (classified by Counties of Massachusetts).*

	Number.	Per Cent.		Number.	Per Cent.
Barnstable,	1	.63	Middlesex,	34	21.52
Berkshire,	9	5.70	Nantucket,	–	–
Bristol,	5	3.16	Norfolk,	9	5.70
Dukes,	1	.63	Plymouth,	10	6.33
Essex,	16	10.13	Suffolk,	16	10.13
Franklin,	14	8.86	Worcester,	23	14.55
Hampden,	6	3.80			
Hampshire,	14	8.86		158	100.00

D. *Nativity of Parents.*

	Number.	Per Cent.
Neither parent foreign born,	139	75.55
Both parents foreign born,	32	17.39
Father (only) foreign born,	7	3.80
Mother (only) foreign born,	6	3.26
	184	100.00

E. *Education of Father.*

	Number.	Per Cent.
Common school,	83	45.11
High school,	56	30.43
Business school,	19	10.33
College or university,	20	10.87
No statistics,	6	3.26
	184	100.00

F. *Religious Census.*

	MEMBERSHIP.		PREFERENCE.		TOTALS.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	14	7.61	4	2.17	18	9.78
Catholic,	19	10.33	–	–	19	10.33
Congregational,	41	22.28	28	15.22	69	37.50
Episcopal,	10	5.44	7	3.80	17	9.24
Hebrew,	2	1.08	6	3.26	8	4.34
Methodist,	10	5.44	4	2.17	14	7.61
Presbyterian,	4	2.17	–	–	4	2.17
Unitarian,	11	5.98	5	2.72	16	8.70
Universalist,	1	.54	9	4.90	10	5.44
Miscellaneous,	3	1.63	–	–	3	1.63
No statistics,	6	3.26	–	–	6	3.26
	121	65.76	63	34.24	184	100.00

G. *Occupation of Fathers.*

	Number.	Per Cent.
Agriculture and horticulture (practical),	48	26.09
Artisans,	42	22.82
Business,	51	27.72
Deceased or no statistics,	10	5.44
Miscellaneous,	14	7.61
Professional,	17	9.24
Retired,	2	1.08
	184	100.00

H. *Intended Vocations of Students.*

	Number.	Per Cent.
Agriculture or horticulture (practical),	73	39.67
Agriculture or horticulture (professional),	64	34.78
Business,	1	.54
Miscellaneous,	1	.54
Professions,	7	3.80
Undecided or no statistics,	38	20.65
	184	99.98

I. *Farm Experience.*

	Number.	Per Cent.
Brought up on a farm,	56	30.43
Not brought up on a farm and having had no, or practically no, farm experience,	75	40.76
Not brought up on a farm, but having had some farm experience,	53	28.80
	184	99.99

J. *Miscellaneous Statistics.*

Average age,	19.22 years.
Number applying for student labor,	110 (59.23 per cent.)

TABLE VI. — *Entrance Statistics of Freshman Class.*

Number of applications,			288
Admitted,		204	
Matriculated,	184		
Failed to report,	20		
Total,		204	
Rejected,		84	
Total,			288
Admitted on certificate,			128
Admitted on examination,			14
Admitted on certificate and examination,			42
			184
Admitted without condition,			113
Admitted with condition,			71
			184

REPORT OF THE TREASURER

FOR THE FISCAL YEAR ENDING NOV. 30, 1912.

BALANCE SHEET.

			DR.	CR.
1911. Dec. 1.	To cash on hand,		$8,229 09	
	To cash on deposit,		15,439 54	
1912. Nov. 30.	To special appropriation receipts, State Treasurer,		149,782 44	
	By special appropriation disbursements,			$143,655 88
	To experiment station receipts,		67,643 34	
	From State Treasurer,	$14,250 00		
	From United States Treasurer,	30,000 00		
	From other sources and transfers,	23,393 34		
	By experiment station disbursements,			68,649 41
	To current account receipts,		266,193 52	
	From United States Treasurer, Morrill fund,	$16,666 66		
	From United States Treasurer, Nelson fund,	16,666 67		
	From State Treasurer endowment fund,	10,613 32		
	From State Treasurer, maintenance,	58,000 00		
	From State Treasurer, administration,	25,000 00		
	From State Treasurer, instruction,	60,000 00		
	From State Treasurer, extension department,	20,000 00		
	From other sources and transfers,	59,246 87		
	By current account disbursements,			275,661 69
	To student trust funds receipts,		66,805 76	
	By student trust funds disbursements,			62,855 80
	By cash on hand,			6,852 44
	By cash on deposit,			16,418 47
			$574,093 69	$574,093 69

STATEMENT OF THE FIRST NATIONAL BANK OF AMHERST WITH THE MASSACHUSETTS AGRICULTURAL COLLEGE.

		DR.	CR.
1911. Dec. 1.	Balance on hand,	$39,976 40[1]	
1912. Nov. 30.	Deposits for year,	551,561 75	
	Interest,	1,088 69	
	Disbursements as per warrants,		$547,301 97
	Balance on hand,		45,324 87[1]
		$592,626 84	$592,626 84

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[1] These amounts are greater Dec. 1, 1911, by $24,536.86, and Nov. 30, 1911, $28,791.20, on account of outstanding checks.

SPECIAL APPROPRIATIONS.

NAME OF APPROPRIATION.	Date made.	Amount of Appropriation.	Amount previously expended.	Amount expended during Fiscal Year.	Amount expended to Date.	Amount received from State Treasurer.	Balance on Hand with State Treasurer.
Architects' fees,[1]	–	–	$1,902 11	$2,675 00	$4,577 11	–	–
Dairy building,	1911	$75,000 00	12,819 86	61,215 25	74,035 11	$74,035 11	$964 89
Equipment,	1911	10,000 00	3,355 23	6,644 77	10,000 00	10,009 00	–
Repairs,	1911	15,000 00	4,579 31	10,420 69	15,000 00	15,000 00	–
Small buildings,	1911	15,000 00	7,792 32	6,982 03	14,774 35	14,774 35	225 65
West experiment station,	1911	7,500 00	5,305 18	2,194 82	7,500 00	7,500 00	–
Improvements,	1912	10,000 00	–	10,000 00	10,000 00	10,000 00	–
Addition to Draper Hall,	1912	25,000 00	–	18,314 53	18,314 53	18,314 53	6,685 47
Miscellaneous,	1912	20,000 00	–	14,779 95	14,779 95	14,779 95	5,220 05
Repairs,	1912	15,000 00	–	8,128 84	8,128 84	8,128 84	6,871 16
	–	$192,500 00	$35,754 01	$141,355 88	$177,109 89	$172,532 78	$19,967 22

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[1] No appropriation made as yet.

CURRENT ACCOUNTS.

Disbursements and Receipts.

ACCOUNTS.	Disbursements from Dec. 1, 1911, to Nov. 30, 1912.	Receipts from Dec. 1, 1911, to Nov. 30, 1912.	Apportionment for Year ending Nov. 30, 1911.	Balance to Credit.
Administration,	$6,177 60	$24 72	$7,240 00	$1,087 12
Agricultural economics,	102 11	–	125 00	22 89
Agricultural education,	1,266 84	122 62	1,100 00	—44 22
Agronomy,	206 40	5 20	200 00	—1 20
Animal husbandry,	264 01	3 89	300 00	39 88
Botanical,	1,558 75	970 63	750 00	161 88
Chemical,	3,958 87	2,648 23	1,400 00	89 36
Dairying,	205 80	20	200 00	—5 60
Dean's office,	353 02	11 00	300 00	—42 02
Economics and sociology,	48 35	–	100 00	51 65
Entomology,	1,359 83	263 99	1,200 00	104 16
Farm,	26,207 33	19,919 02	3,000 00	—3,288 31
Farm administration,	212 66	11 38	200 00	—1 28
Floriculture,	3,887 99	2,869 75	1,300 00	281 76
Forestry,	184 57	–	400 00	215 43
General agriculture,	537 28	51 63	200 00	—285 65
General horticulture,	2,791 01	599 54	2,000 00	—191 47
General maintenance,	63,093 90	22,094 07	46,500 00	5,500 17
Graduate school,	1 50	–	–	2,366 13
Grounds,	3,114 11	85	3,500 00	386 74
History and government,	19 93	–	100 00	80 07
Landscape gardening,	444 55	473 03	250 00	278 48
Language and literature,	544 37	–	750 00	205 63
Library,	6,591 12	590 40	6,000 00	— 72
Market gardening,	4,452 21	1,851 94	2,400 00	—200 27
Mathematics,	209 81	–	350 00	140 19
Military,	1,547 43	–	1,550 00	2 57
Physics,	227 94	–	525 00	297 06
Physical education,	570 99	121 50	500 00	50 51
Pomology,	3,502 47	1,233 52	2,000 00	—268 95
Poultry husbandry,	3,214 79	1,235 41	2,000 00	20 62
President's office,	659 08	2 18	1,000 00	343 10
Registrar's office,	383 00	60	400 00	17 60
Rural sociology,	39 69	–	100 00	60 31
Salaries,	113,525 51	–	110,593 34	—2,932 17
Treasurer's office,	891 20	6 88	800 00	—84 32
Veterinary department,	1,464 03	19 35	1,400 00	—44 68
Zoölogy,	571 58	329 69	150 00	—91 89
State Treasurer: —				
Endowment fund,	–	10,613 32	–	–
Maintenance,	–	58,000 00	–	–
Scholarship,	–	25,000 00	–	–
Instruction,	–	60,000 00	–	–
United States Treasurer: —				
Morrill fund,	–	16,666 66	–	–
Nelson fund,	–	16,666 67	–	–
	$254,391 63	$242,407 87	$200,883 34	$11,803 31
Balance beginning fiscal year Dec. 1, 1911,	–	31,272 38[1]	–	—7,482 75
Balance on hand Nov. 30, 1912,	19,288 62	–	–	–
	$273,680 25	$273,680 25	$200,883 34	$4,320 56

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[1] This balance is increased by $5,411.94 on account of extension service deficit, shown in report of that department.

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1911,[1]	–	$31,236 57
Institution receipts Nov. 30, 1912,	–	55,461 22
State Treasurer's receipts Nov. 30, 1912,	–	153,613 32
United States Treasurer's receipts Nov. 30, 1912,	–	33,333 33
Total disbursements,	$254,391 63	–
	$254,391 63	$273,644 44
Bills receivable Dec. 1, 1911, deducted,	–	2,265 82
Bills payable Dec. 1, 1911, deducted,	3,059 45	–
	$251,332 18	$271,378 62
Bills receivable Nov. 30, 1912,	–	4,058 51
Bills payable Nov. 30, 1912,	2,964 94	–
Balance,	21,140 01	–
	$275,437 13	$275,437 13

[1] This amount is greater by $5,411.94 than previous report on account of taking out deficit of the extension service. See the extension service report.

Comparative Disbursements and Receipts for 1911-12.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1911.	1912.	1911.	1912.
Administration,	$6,233 96	$6,177 60	$2 36	$24 72
Agricultural economics,	91 28	102 11	–	–
Agricultural education,	5,705 78	1,266 84	17 67	122 52
Agricultural division,	22,788 40	26,207 33	19,052 37	19,919 02
Agronomy,	–	206 40	–	5 20
Animal husbandry,	–	264 01	–	3 89
Botanical,	1,442 56	1,558 75	769 55	970 63
Chemical,	3,520 50	3,958 87	2,328 43	2,648 23
Dairying,	–	205 80	–	20
Dean's office,	202 45	353 02	–	11 00
Economics and sociology,	–	48 35	–	–
Entomology,	1,084 82	1,359 83	275 79	263 99
Extension service,	20,811 41	–	2,864 87	–
Farm administration,	–	212 66	–	11 38
Floriculture,	3,499 93	3,887 99	2,761 82	2,869 75
Forestry,	392 77	184 57	50	–
General agriculture,	–	537 28	–	51 63
General horticulture,	2,585 00	2,791 01	659 80	599 54
General maintenance,	39,136 73	63,093 90	10,573 42	22,094 07
Graduate school,	1,339 18	1 50	120 00	–
Grounds,	1,900 61	3,114 11	1 70	85
History and government,	–	19 93	–	–
Landscape gardening,	433 72	444 55	256 93	473 03
Language and literature,	598 99	544 37	–	–
Library,	5,542 46	6,591 12	436 91	590 40
Market gardening,	4,413 12	4,452 21	2,293 74	1,851 94
Mathematics,	361 75	209 81	10	–
Military,	1,939 42	1,547 43	24 79	–
Physics,	–	227 94	–	–
Physical education,	497 60	570 99	119 00	121 50
Political science,	85 07	–	–	–
Pomology,	3,425 41	3,502 47	1,156 58	1,233 52
Poultry husbandry,	–	3,214 79	–	1,235 41
President's office,	873 68	659 08	28 44	2 18
Registrar's office,	302 13	383 00	–	60
Rural sociology,	–	39 69	–	–
Salaries,	84,132 15	113,525 51	–	–
Treasurer's office,	764 18	891 20	–	6 88
Veterinary,	1,343 35	1,464 03	17 50	19 35
Zoölogy,	493 40	571 58	346 30	329 69

Comparative Disbursements and Receipts — Concluded.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1911.	1912.	1911.	1912.
State Treasurer: —				
Endowment fund,	–	–	$10,613 32	$10,613 32
Maintenance,	–	–	35,000 00	58,000 00
Scholarship,	–	–	15,000 00	25,000 00
Instruction,	–	–	47,500 00	60,000 00
Extension service,	–	–	–	–
Agricultural education,	–	–	5,000 00	–
Veterinary,	–	–	1,000 00	–
Student labor,	–	–	7,500 00	–
Graduate school,	–	–	2,500 00	–
United States Treasurer: —				
Morrill fund,	–	–	16,666 66	16,666 66
Nelson fund,	–	–	16,666 67	16,666 67
	$215,941 81	$254,391 63	$201,555 22	$242,407 87
Balance beginning fiscal year,	–	–	25,211 22	31,272 38[1]
Balance at close of fiscal year,	25,824 63	19,288 62	–	–
	$241,766 44	$273,680 25	$226,766 44	$273,680 25

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[1] In closing accounts the balance of $35.81, Old Creamery House, was used to close up current accounts.

EXPERIMENT STATION.

Disbursements and Receipts.

ACCOUNTS.	Disbursements from Dec. 1, 1911, to Nov. 30, 1912.	Receipts from Dec. 1, 1911, to Nov. 30, 1912.	Apportionment for Year ending Nov. 30, 1912.	Balance to Credit.
Administration,	$1,690 19	$2 94	$1,800 00	$112 75
Agricultural,	4,469 62	1,920 80	2,100 00	—449 02
Asparagus,	733 84	–	500 00	—233 84
Botanical,	1,127 23	6 17	1,500 00	378 94
Chemical,	9,397 06	8,980 25	2,900 00	2,483 19
Cranberry,	3,228 96	2,337 89	3,000 00	2,108 93
Entomological,	466 03	–	700 00	233 97
Fertilizer,	–	–	–	–
Freight,	275 76	80	300 00	25 04
Feed law,	4,345 00	3,750 00	3,750 00	1,081 45
Graves orchard,	676 33	30 00	300 00	—346 33
Horticultural,	1,539 15	50	1,350 00	—188 65
Library,	89 48	–	300 00	210 52
Meteorology,	397 05	–	400 00	2 95
Publications,	1,263 53	–	2,400 00	1,136 47
Salaries,	29,640 69	–	37,500 00	7,859 31
Treasurer's office,	253 18	–	350 00	96 82
Veterinary,	275 16	113 00	250 00	87 84
Hatch fund,	–	15,000 00	–	–
Adams fund,	–	15,000 00	–	–
State fund,	–	10,500 00	–	–
Poultry,	247 55	–	250 00	2 45
Fertilizer law,	8,533 60	10,000 99	–	1,467 39
	$68,649 41	$67,643 34	$59,650 00	$17,288 02
Balance beginning fiscal year, Dec. 1, 1911,	–	4,090 36	–	—1,217 84
Balance on hand Nov. 30, 1912,	3,084 29	–	–	–
	$71,733 70	$71,733 70	$59,650 00	$16,070 18

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1911,	–	$4,090 36
Receipts from State Treasurer,	–	14,250 00
Receipts from United States Treasurer,	–	30,000 00
Receipts from other sources,	–	23,393 34
Total disbursements,	$68,649 41	–
	$68,649 41	$71,733 70
Bills receivable Nov. 30, 1912,	–	2,394 95
Bills payable Nov. 30, 1912,	505 53	–
Balance,	4,973 71	–
	$74,128 65	$74,128 65

Comparative Disbursements and Receipts for 1911–12.

Accounts.	Disbursements.		Receipts.	
	1911.	1912.	1911.	1912.
Administration,	$1,669 79	$1,690 19	$123 79	$2 94
Agriculture,	4,864 07	4,469 62	2,128 14	1,920 80
Asparagus,	748 63	733 84	–	–
Botanical,	1,577 35	1,127 23	20 82	6 17
Chemical,	9,809 16	9,397 06	7,165 66	8,980 25
Cranberry,	4,038 98	3,228 96	4,232 00	2,337 89
Entomology,	588 10	466 03	2 50	–
Fertilizer,	–[1]	8,533 60	6,094 83	10,000 99
Freight,	294 49	275 76	–	80
Feed law,	2,891 44	4,345 00	3,000 00	3,750 00
Graves orchard,	194 79	676 33	–	30 00
Horticulture,	1,439 97	1,539 15	4 36	50
Library,	161 56	89 48	–	–
Meteorology,	322 16	397 05	–	–
Publications,	1,726 40	1,263 53	–	–
Salaries,	33,899 31	29,640 69	–	–
Treasurer's office,	182 12	253 18	–	–
Veterinary,	238 16	275 16	5 00	113 00
Hatch fund,	–	–	15,000 00	15,000 00
Adams fund,	–	–	15,000 00	15,000 00
State fund,	–	–	10,500 00	10,500 00
Poultry,	–	247 55	–	–
Tobacco experiments,	340 20	–	–	–
	$64,986 68	$68,649 41	$63,277 10	$67,643 34
Balance beginning fiscal year,	–	–	5,799 94	4,090 36
Balance on hand Nov. 30, 1912,	4,090 36	3,084 29	–	–
	$69,077 04	$71,733 70	$69,077 04	$71,733 70

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[1] Disbursements were included under plant and animal chemistry.

EXTENSION SERVICE.

Disbursements and Receipts.

	Disbursements.	Receipts.	Apportionment.	Balance.
Miscellaneous,	–	–	$980 00	$980 00
From State Treasurer,	–	$20,000 00	–	–
Administration,	$14,459 53	462 92	13,320 00	—676 61
Correspondence courses,	840 65	616 39	1,000 00	775 74
Itinerant instruction,	310 79	55 59	200 00	—55 20
Demonstration orchards,	468 84	12 06	600 00	143 22
Dairy improvement,	377 71	93 78	600 00	316 07
Boys' and Girls' Club,	164 39	12 06	–	—152 33
M. A. C. Improvement Association,	161 64	33 78	200 00	72 14
Winter school,	2,108 38	1,901 64	1,500 00	1,293 26
Poultry convention,	124 66	–	300 00	175 34
Farmers' week,	693 83	23 11	500 00	—170 72
Beekeepers' course,	151 61	–	200 00	48 39
Packing school,	463 89	528 70	–	64 81
Summer school,	6 40	43 12	–	36 72
Conference Rural Social workers,	511 85	2 50	–	—509 35
District field agent,	425 89	–	600 00	174 11
	$21,270 06	$23,785 65	$20,000 00	$4,079 80
Balance Dec. 1, 1911,	5,411 94	–	–	—1,564 21
Balance Nov. 30, 1912,	–	2,896 35	–	–
	$26,682 00	$26,682 00	$20,000 00	$2,515 59

Summary.

	Disbursements.	Receipts.
Overdraft, Dec. 1, 1911,	$5,411 94	$3,785 65
Receipts, Nov. 30, 1912,	–	–
Receipts from State Treasurer,	–	20,000 00
Disbursements, Nov. 30, 1912,	21,270 06	–
	$26,682 00	$23,785 65
Bills payable Dec. 1, 1911, deducted,	431 92	–
	$26,250 08	$23,785 65
Bills receivable Nov. 30, 1912,	–	101 37
Bills payable Nov. 30, 1912,	916 95	–
Balance overdrawn Nov. 30, 1912,	–	3,280 01
	$27,167 03	$27,167 03

AGRICULTURAL DIVISION.

Disbursements and Receipts.

	Disbursements.	Receipts.
Agronomy,	$206 40	$5 20
Animal husbandry,	264 01	3 89
Dairying,	205 80	20
Farm administration,	212 66	11 38
General agriculture,	537 28	51 63
Poultry husbandry,	3,214 79	1,235 41
Farm,	26,207 33	19,919 02
Division totals,	$30,848 27	$21,226 73

Summary.

	Dr.	Cr.
By total division receipts,		$21,226 73
By bills receivable,		2,930 15
By net apportionment,		6,100 00
To total disbursements,	$30,848 27	
To bills payable,	294 16	
To balance,	. . .	885 55
	$31,142 43	$31,142 43

Inventory of Quick Assets.

	Nov. 30, 1911.	Nov. 30, 1912.
Inventory of produce,	$4,728 73	$7,010 93
Inventory of cattle,	10,823 00	11,148 00
Inventory of swine,	485 00	731 00
Inventory of horses,	4,080 00	4,090 00
Inventory of poultry,	614 25	1,524 15
Inventory of sheep,	–	200 00
	$20,730 98	$24,704 08

HORTICULTURAL DIVISION.

Disbursements and Receipts.

	Disbursements.	Receipts.
Floriculture,	$3,887 99	$2,869 75
Forestry,	184 57	–
General horticulture,	2,791 01	599 54
Grounds,	3,114 11	85
Landscape gardening,	444 55	473 03
Market gardening,	4,452 21	1,851 94
Pomology,	3,502 47	1,233 52
	$18,376 91	$7,028 63

Summary.

	Dr.	Cr.
By total division receipts,		$7,028 63
By bills receivable,		888 65
By apportionment,		11,850 00
To total division disbursements,	$18,376 91	
To bills payable,	356 81	
To balance,	1,033 56	
	$19,767 28	$19,767 28

Inventory of Quick Assets.

	Nov. 30, 1911.	Nov. 30, 1912.
Inventory of supplies,	$1,064 00	$621 25

INVENTORY — REAL ESTATE.

Land (Estimated Value).

Baker place,	$2,500 00
Bangs place,	2,350 00
Clark place,	4,500 00
College farm,	37,000 00
Cranberry land,	11,063 00
Harlow farm,	3,284 63
Kellogg farm,	5,868 45
Louisa Baker place,	5,636 91
Old creamery place,	1,000 00
Pelham quarry,	500 00
Westcott place,	2,250 00
Allen place,	500 00
Charmbury place,	450 00
Loomis place,	415 00
Hawley & Brown place,	675 00
Newell farm,	2,800 00
	$80,792 99

College Buildings (Estimated Value).

Apiary,	$3,000 00
Animal husbandry building,	10,000 00
Chemical laboratory,	8,000 00
Clark hall,	67,500 00
Cold storage laboratory,	12,000 00
Dairy building,	75,000 00
Dairy barn and storage,	30,000 00
Dining hall,	35,000 00
Drill hall and gun shed,	10,000 00
Durfee range and glass houses, old,	10,000 00
Durfee range and glass houses, new,	15,000 00
Entomology building,	80,000 00
Farmhouse,	2,500 00
French hall,	17,000 00
Horse barn,	5,000 00
Horticultural barn,	2,500 00
Horticultural tool shed,	2,000 00
Machinery barn,	4,000 00
Mathematical building,	6,000 00
North dormitory,	25,000 00
Physics laboratory,	5,500 00
Poultry breeding house,	600 00
Poultry brooder house,	1,000 00
Poultry incubator cellar and demonstration building,	1,400 00
Poultry laboratory,	1,300 00
Poultry laying house,	1,800 00
Poultry mechanics and storage building,	1,900 00
Power plant and storage building,	18,500 00
President's house,	12,000 00
Quarantine barn,	200 00
Sheep shed,	1,400 00
Small plant house, with vegetable cellar and cold grapery,	4,700 00

College Buildings (Estimated Value) — Concluded.

South dormitory,	$35,000 00
Stone chapel,	30,000 00
Three houses on Stockbridge Road,	5,000 00
Veterinary laboratory and stable,	23,500 00
Waiting station,	500 00
Wilder hall,	37,500 00
Young stock barn,	6,500 00
	$607,800 00

College Equipment (Estimated Value).

Administrative division: —	
Dean's office,	$212 20
President's office,	952 40
Registrar's office,	263 25
Treasurer's office,	2,360 00
Agricultural division: —	
Agronomy,	1,737 53
Animal husbandry,	1,173 67
Dairy,	7,545 64
Farm administration,	1,278 49
Farm department,	29,749 69
Poultry,	3,321 63
Dining hall,	4,447 50
Extension department,	1,659 35
General maintenance: —	
College supplies,	217 82
Fire apparatus,	1,332 32
General maintenance,	70,890 03
Janitor supplies,	253 83
Water mains,	8,350 00
General science: —	
Apiary,	1,145 67
Botanical,	7,991 17
Chemical,	10,642 63
Entomology,	5,921 89
Microbiology,	2,000 00
Mathematics,	3,312 50
Physics,	2,559 50
Veterinary,	8,390 62
Zoölogical laboratory,	8,945 53
Zoölogical museum,	6,411 93
History and political science,	20 75
Horticultural division: —	
Floriculture,	6,926 66
Forestry,	1,318 64
General horticulture,	9,715 28
Grounds,	248 12
Landscape gardening,	4,575 78
Market gardening,	1,383 49
Pomology,	2,947 71
Humanities, division of: —	
Economics and sociology,	93 00
Language and literature,	279 85

College Equipment (Estimated Value) — Concluded.

Library,	$67,573 35
Military,	1,264 42
Physical education,	2,263 12
Rural social science: —	
Agricultural economics,	237 25
Agricultural education,	716 39
Rural social service,	90 35
Textbooks,	518 55
Trophy room,	1,504 80
	$294,744 30

Experiment Station Buildings (Estimated Value).

Agricultural laboratory,	$15,000 00
Agricultural barns,	5,000 00
Agricultural farmhouse,	1,500 00
Agricultural glass house,	500 00
Cranberry buildings,	2,720 00
Plant and animal chemistry laboratory,	30,000 00
Plant and animal chemistry barns,	4,000 00
Plant and animal chemistry dairy,	2,000 00
Six poultry houses,	600 00
Entomological laboratory and glass house,	850 00
	$62,170 00

Experiment Station Equipment (Estimated Value).

Agricultural laboratory,	$6,392 02
Botanical laboratory,	5,101 20
Chemical laboratory,	16,672 04
Cranberry station,	2,167 49
Director's office,	3,954 75
Entomological laboratory,	23,242 50
Horticultural laboratory,	1,762 00
Library,	320 00
Meteorology laboratory,	1,087 00
Poultry department,	543 35
Treasurer's office,	381 40
Veterinary laboratory,	121 94
	$61,745 69

Inventory Summary.

Land,	$80,792 99
College buildings,	607,800 00
College equipment,	294,744 30
Experiment station buildings,	62,170 00
Experiment station equipment,	61,745 69
	$1,107,252 98

STUDENTS' TRUST FUND ACCOUNTS.

	Disbursements for Year ending Nov. 30, 1912.	Receipts for Year ending Nov. 30, 1912.	Balance on Hand Nov. 30, 1912.	Balance brought forward Dec. 1, 1911.
Athletics,	$8,217 80	$7,430 50	$2,749 35	$3,536 65
Draper Hall,	38,835 04	39,783 05	—742 79	—1,690 80
"College signal,"	1,913 81	1,972 48	608 83	550 16
Keys,	15 00	16 25	31 75	30 50
Harlow farm,	96 45	120 00	—141 08	164 63
Student deposits,	5,792 67	7,119 86	1,881 74	554 55
Kellogg farm,	152 78	141 66	24 57	35 69
Trophy room tax,	945 56	959 91	622 92	608 57
1914 index,	94 03	119 00	24 97	–
Textbooks,	4,766 89	4,811 78	426 93	382 04
1913 index,	1,422 18	1,357 42	28 42	93 18
1912 index,	68 52	44 75	–	23 77
Kappa Sigma House,	47 70	47 70	–	–
Uniforms,	487 37	2,281 40	2,633 65	239 62
	$62,855 80	$66,805 76	$9,033 13	$6,054 73

DETAILED STATEMENT OF THE DINING HALL.

	Liabilities.	Resources.
Dec. 1, 1911, overdraft,	$1,690 80	–
Nov. 30, 1912, total disbursements,	38,709 75	–
Nov. 30, 1913, outstanding bills,	703 56	–
Nov. 30, 1912, total collections,	–	$39,393 55
Nov. 30, 1912, total collections outstanding,	–	1,018 11
Nov. 30, 1912, inventory,	–	1,757 50
Nov. 30, 1912, balance,	1,065 05	–
	$42,169 16	$42,169 16

ENDOWMENT FUND.[1]

	Principal.	Income.
United States grant (5 per cent.),	$219,000 00	$7,300 00
Commonwealth grant (3½ per cent.),	142,000 00	3,313 32
		$10,613 32

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[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

BENEFICIARY FUNDS.

Burnham Emergency Fund.

	Market Value Dec. 1, 1912.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $890,	$1,780 00	$2,000 00	$80 00
Two bonds Western Electric Company 5s, at $1,010,	2,020 00	2,000 00	100 00
Unexpended balance Dec. 1, 1911,	–	–	600 55
	$3,800 00	$4,000 00	$780 55
To amount paid for C. A. Goessmann library,	–	–	1,000 00
Overdraft Dec. 1, 1912,	–	–	$219 45

Library Fund.

Five bonds New York Central & Hudson River Railroad Company 4s, at $920,	$4,600 00	$5,000 00	$200 00
Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at $930,	4,650 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at $108,	216 00	200 00	10 50
Amherst Savings Bank, deposit,	167 77	167 77	6 18
	$9,633 77	$10,367 77	$416 68
Transferred to college library account,	–	–	416 68

SPECIAL FUNDS.

Endowed Labor Fund (the Gift of a Friend of the College).

Two bonds American Telephone and Telegraph Company 4s, at $890,	$1,780 00	$2,000 00	$80 00
Two bonds Lake Shore & Michigan Southern Railroad Company 4s, at $930,	1,860 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s,	920 00	1,000 00	40 00
Amherst Savings Bank, deposit,	143 39	143 39	5 72
One bond Metropolitan Street Railway, Kansas City Company 5s, at	990 00	1,000 00	50 00
	$5,693 39	$6,143 39	$255 72
Unexpended balance Dec. 1, 1911,	–	–	247 39
Cash on hand Dec. 1, 1912,	–	–	$503 11

Whiting Street Scholarship Fund.

One bond New York Central debenture 4s,	$920 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	271 64	271 64	10 84
	$1,191 64	$1,271 64	$50 84
Unexpended balance Dec. 1, 1911,	–	–	18 47
	–	–	$69 31
Disbursements for scholarships for fiscal year ending Nov. 30, 1912,	–	–	23 00
Cash on hand Dec. 1, 1912,	–	–	$46 31

Hills Fund.

	Market Value Dec. 1, 1912.	Par Value.	Income.
Northampton Institution for Savings, deposit,	$1,180 00	$1,180 00	$20 65
One bond American Telephone and Telegraph Company 4s,	890 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 4s,	920 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 3½s,	800 00	1,000 00	35 00
Two bonds Metropolitan Street Railway of Kansas City 5s, at $990,	1,980 00	2,000 00	100 00
Three bonds Pacific Telephone and Telegraph Company 5s, at $990,	2,970 00	3,000 00	150 00
One bond Western Electric Company 5s,	1,010 00	1,000 00	50 00
Boston & Albany Railroad stocks, 3⅝ shares at $213,	772 12	362 00	31 68
Amherst Savings Bank, deposit,	72 75	72 75	2 88
Electric Securities Company stocks, 59/50 shares at $1,000,	1,180 00	1,180 00	29 50
	$10,594 87	$10,614 75	$499 71
Less overdraft Dec. 1, 1911,	–	–	170 55
	–	–	$329 16
On April 17, 1912: We withdrew our deposit from the Northampton Institution for Savings and invested it with the Mary Robinson portion of funds in the purchase of two bonds of the Electric Securities Company of New York at par, $1,180 00			
Disbursements by floriculture and botanical departments for fiscal year ending Nov. 30, 1912,	–	–	216 58
Cash on hand Dec. 1, 1912,	–	–	$112 58

Mary Robinson Fund.

Northampton Institution for Savings,	$820 00	$820 00	$14 35
Boston & Albany Railroad stock, ⅜ share at $213,	79 86	38 00	3 32
Electric Securities Company stocks, 41/50 share at $1,000,	820 00	820 00	20 50
	$899 86	$858 00	$38 17
Unexpended balance Dec. 1, 1910,	–	–	89 89
	–	–	$128 06
On April 17, 1912: — We withdrew our deposit from the Northampton Institution for Savings and invested it with a portion of the Hills fund in the purchase of two bonds of the Electric Securities Company of New York at par, $820 00			
Disbursements for fiscal year ending Nov. 30, 1912,	–	–	28 66
Cash on hand Dec. 1, 1912,	–	–	$99 40

Grinnell Prize Fund.

Ten shares New York Central & Hudson River Railroad stock at $108,	$1,080 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1911,	–	–	195 74
	$1,080 00	$1,000 00	$245 74
Disbursements for prizes,	–	–	50 00
Cash on hand Dec. 1, 1912,	–	–	$195 74

Massachusetts Agricultural College (Investment).

	Market Value Dec. 1, 1912.	Par Value.	Income.
One share New York Central & Hudson River Railroad stock,	$108 00	$100 00	$5 00
Unexpended balance Dec. 1, 1911,	–	–	55 45
Cash on hand Dec. 1, 1912,	–	–	$60 45

Gassett Scholarship Fund.

One bond New York Central & Hudson River Railroad debenture 4s,	$920 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	11 64	11 64	44
	$931 64	$1,011 64	$40 44
Unexpended balance Dec. 1, 1911,	–	–	10 51
	–	–	$50 95
Disbursements for scholarships for fiscal year ending Nov. 30, 1912,	–	–	20 00
Cash on hand Dec. 1, 1912,	–	–	$30 95

Danforth Keyes Bangs Fund.

Two bonds Pacific Telephone and Telegraph Company 5s, at $990,	$1,980 00	$2,000 00	$100 00
Two bonds Union Electric Light and Power Company 5s, at $990,	1,980 00	2,000 00	100 00
Two bonds American Telephone and Telegraph Company 4s, at $890,	1,780 00	2,000 00	80 00
Interest from student loans,	–	–	10 45
	$5,740 00	$6,000 00	$290 45
Unexpended balance Dec. 1, 1911,	–	–	531 57
	–	–	$822 02
Net loans to students during year,	–	–	420 00
Cash on hand Dec. 1, 1912,	–	–	$402 02

John C. Cutter Fund.

One bond Pacific Telephone and Telegraph Company 5s,	$990 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1911,	–	–	78 33
	–	–	$128 33
Disbursements for fiscal year to date,	–	–	53 61
Cash on hand Dec. 1, 1912,	–	–	$74 72

SUMMARY OF BALANCES ON HAND OF THE INCOME FROM FUNDS HELD IN TRUST BY THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Hills fund,	$112 58
Endowed labor fund,	503 11
Whiting Street scholarship fund,	46 31
Mary Robinson fund,	99 40
Grinnell prize fund,	195 74
Gassett scholarship fund,	30 95
Massachusetts Agricultural College investment,	60 45
Danforth Keyes Bangs fund,	402 02
John C. Cutter fund,	74 72
	$1,525 28
Burnham emergency fund overdraft,	219 45
	$1,305 83

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the treasurer, Fred C. Kenney, for the year ending Nov. 30, 1912. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHAS. A. GLEASON,
Auditor.

AMHERST, Dec. 23, 1912.

HISTORY OF SPECIAL FUNDS.

Burnham emergency fund: —	
A bequest of $5,000 from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college directed that $1,000 of this fund should be used in the purchase of the Newell land and Goessmann library. The fund now shows an investment of	$4,000 00
Library fund: —	
The library of the college at the present time contains about 38,000 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887 Elizur Smith of Lee, Mass., gave $1,215. These were the largest bequests, and amount now to	10,000 00
Endowed labor fund: —	
Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students,	5,000 00

THE M. A. C. BULLETIN

AMHERST, MASS.

Vol. V. No. I. For January, 1913

Published Six Times a Year by the College.
Jan., Feb., Mar., May, Sept., Oct.

ENTERED AS SECOND-CLASS MAIL MATTER AT THE POST OFFICE, AMHERST, MASS.

Public Document No. 31

CATALOGUE
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE,
1912-1913.

FIFTIETH ANNUAL REPORT.
PART II.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1913.

Massachusetts Agricultural College

CHANGES IN CURRICULUM

To Take Effect September 1, 1913

CHANGES IN MAJORS

The major in general horticulture will be discontinued.

A major in microbiology will be offered with the following courses recommended:

Courses.	No.	Credits.
Microbiology	1	5
Microbiology	2	5
Microbiology	3	3
Microbiology	4	3
Chemistry	3	5
Chemistry	4	5
Chemistry	5	3
Chemistry	6	3
		32

Courses 9 in Chemistry; 3, 4, 5 in Botany; 3, 4, 5, 6 in Zoology; 3, 4, in Veterinary Science, together with German and French, are suggested as collateral lines. Dairying 1 and Agronomy 5 are essential to a grasp of the larger problems involved in microbiology as applied to Agriculture.

NEW COURSES OFFERED

Department of Microbiology:

1. *Morphological, Cultural and Physical Microbiology.*

Types of microorganisms, technic of handling, methods of culture, and functions of microorganisms are considered. This course is elementary and fundamental to all applied and special microbiological studies, and therefore is made a prerequisite to all courses offered; two hours or two credits are assigned to lectures, text-book requirements and recitations; this time will be scheduled. Six hours or three credits are assigned to laboratory exercises; only one hour of the six is scheduled, the remaining five hours are arranged with the instructor. Total, five credits. Open to Juniors and Seniors during the fall semester.

2. *Agricultural Microbiology.*

This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture—the microbiological features of air, water, sewage, soil, dairy, fermentations, food, vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control, or sanitary and hygienic practices. These subjects will be demonstrated by illustrative and typical laboratory exercises, which for each subject, on account of time limitations, must be very elementary and greatly restricted. Prerequisite: Microbiology, Course 1. Two hours or two credits are assigned to lectures, text-book requirements and recitations; this time will be scheduled. Six hours or three credits are assigned to laboratory exercises; only one hour of the six is scheduled, the remaining five hours are arranged with the instructor. Total, five credits. Open to Juniors and Seniors during the spring semester.

NOTE.—Courses 1 and 2 are especially adapted to those who wish a general, comprehensive, although elementary survey of Agricultural Microbiology.

3. *Advanced Morphological, Cultural and Physiological Microbiology.*

The purpose of this course is to prepare the student for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technic and methods of culture, together with a more extensive knowledge of microorganisms and their functions. Prerequisites: Microbiology, Courses 1 and 2; Chemistry, Courses 5 and 6. Six hours or three credits are assigned to laboratory exercises; only one hour of the six is scheduled, the remaining five hours are arranged with the instructor. Total, three credits. Open to Juniors and Seniors in the fall semester.

4. *Advanced Agricultural Microbiolody.*

A knowledge of the subjects mentioned in Course 2 cannot be obtained without a more extensive training in microbiological practices, as found in Course 3. With this it is possible to continue the work of Course 2. Prerequisites: Microbiology, Courses 1, 2 and 3; Chemistry, Courses 5 and 6. Six hours or three credits are assigned to the laboratory exercises; only one hour of the six is scheduled, the remaining five hours are arranged with the instructor. Total, three credits. Open to Juniors and Seniors in the spring semester.

5. *Soil Microbiology.*

Such subjects as the number and development of microorganisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention. Prerequisite: Microbiology 1. Six hours or three credits are assigned to laboratory exercises; only one hour of the six is scheduled, the remaining five hours are arranged with the instructor. Open to Juniors and Seniors during the fall semester.

6. *Dairy Microbiology.*

Special emphasis will be placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease producing organisms; the value of straining, aeration, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bacterial content of butter; a passing survey of the microbiology of cheeses; a study of special dairy products as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represent a list of topics considered. Prerequisite: Microbiology 1, and Dairying 1. Six hours or three credits are assigned to laboratory exercises; only one hour of the six is scheduled, the remaining five hours are arranged with the instructor. Open to Juniors and Seniors during the fall and spring semesters. See Dairying 3.

7. *Food Microbiology.*

A study of food preservation by means of drying, canning, refrigerating, and addition of chemicals, will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased foods, will receive consideration. Contamination of food supplies by means of water, handling, exposure, diseased persons, etc., is of especial significance and will be demonstrated by laboratory exercises. Prerequisite: Microbiology 1. Six hours or three credits are assigned to laboratory exercises; only one of the six is scheduled, the remaining five hours are arranged with the instructor. Open to Juniors and Seniors during the fall semester. (Will not be given during the school year of 1913-14.)

8. Hygienic Microbiology.

An attempt will be made to select for this course certain material which should be the possession of every individual, and which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which microorganisms enter the body, the influence of body fluids and tissues upon them, body reactions with microorganisms (susceptibility and immunity); the microorganisms of some of the most important infectious diseases, methods of control, including disinfectants and disinfection, antiseptics, and anti- and asepsis, will be treated. Prerequisite: Microbiology 1. Six hours or three credits are assigned to laboratory exercises; only one of the six is scheduled, the remaining five hours are arranged with the instructor. Open to Juniors and Seniors during the spring semester.

Department of Veterinary Science.

The following courses will be offered in place of those now advertised:

FIRST SEMESTER

1. ***Veterinary Hygiene and Stable Sanitation.*** This course is intended to familiarize the student with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals.

Juniors and Seniors, 3 hours. Credit 3. PROFESSOR PAIGE

3. ***Comparative (Veterinary) Anatomy.*** The anatomy of the horse is studied in detail, and that of other farm animals compared with it where differences exist. This course is essential for those students wishing to elect Course 4.

Juniors and Seniors, 3 hours. Credit 3. PROFESSOR PAIGE

5. ***Essentials of General Pathology.*** This course is planned to introduce the student to some of the essential anatomical, histological and general physiological phenomena, essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis will be considered in the laboratory. The various chemical and biological reactions and tests will be presented from the standpoint of pure science, showing applications of chemistry and biology. The course will serve to liberally educate and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work. Juniors and Seniors, two 3 hour laboratory periods. Credit 3.

ASSISTANT PROFESSOR GAGE

7. ***Avian Pathology.*** (Course in Poultry Diseases.) The object of this course is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. The work will consist of a systematic study of the diseases of the alimentary tract, liver and abdominal region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites will be considered; also diseases of the skin and reproductive organs. Lectures and demonstrations. Juniors and Seniors, 3 hours. Credit 3.

ASSISTANT PROFESSOR GAGE

SECOND SEMESTER

2. *General Veterinary Pathology, Materia Medica and Therapeutics.* In this course such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, prevention and treatment of disease. The course in Pathology is followed by one in Materia Medica and Therapeutics, dealing with the origin, preparation, pharmachology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered. Juniors and Seniors. 3 hours. Credit 3. PROFESSOR PAIGE

4. *Theory and Practice of Veterinary Medicine; General, Special and Operative Surgery.* A course intended to familiarize the student with the various medical and surgical diseases of the different species of farm animals. Particular attention is given to diagnosis and first-aid treatment. The student is taught the technic of simple surgical operations, that can with safety be performed by the stock owner. This course should be preceded by Course 3, and taken in conjunction with Course 2. Lectures, demonstrations and practice. Juniors and Seniors, 3 hours. Credit 3.

PROFESSOR PAIGE

6. *Essentials of General Animal Pathology.* This is a continuation of Course 5, and is devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases are prepared for microscopical study. Some of the biological products used in protecting animals against disease will be considered. Juniors and Seniors, two 3-hour laboratory periods. Credit 3. ASSISTANT PROFESSOR GAGE

Department of Mathematics.

Course 5. *Mensuration and Computation.* An elective, three hours per week, during the first semester, Junior year. The course includes a review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations.

Also the graph, mensuration of plane and solid figures, weights and measures, and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of wood working; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; compution of areas from simple measurements. Three hours, credit 3.

MR. MACHMER

Department of Entomology

Course in Evolution to be Offered for One Year

A discussion of the subject from a general point of view; its philosophical and humanitarian aspects; its influence upon modern thought. The course comprises two lecture periods a week, and is open to Juniors and Seniors. It is given during the first semester. Collateral reading from assigned books required. Two hours, credit 2. ASSOCIATE PROFESSOR CRAMPTON

MINOR CHANGES IN COURSES NOW OFFERED

The following changes in courses now given will be made: The credit in courses, 7, 8, 9 and 10 in French will be changed from three lecture periods to two lecture periods with corresponding changes in the credits for the coming year. The following changes will be made in the numbering of courses in Agricultural Economics, namely: Course 4 changed to course 3; course 8 to course 7; course 7 to course 8.

Without excluding other scientific and classical studies, and including military tactics to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. — *Act of Congress, July 2, 1862.*

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST.

CATALOGUE, 1912-1913.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1913.

Approved by
The State Board of Publication.

THE MASSACHUSETTS AGRICULTURAL COLLEGE.

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue. Special publication will be made should it become necessary on account of important changes.

Calendar.

1913-14.

Regular Courses.

1913.

January 6, Monday, 1.10 P.M.,	Winter recess ends; chapel.
January 24, Friday,	Semester examinations begin.
February 3, Monday, 1.10 P.M.,	Second semester begins; chapel.
March 28, Friday, 6 P.M.,	Spring recess begins.
April 7, Monday, 1.10 P.M.,	Spring recess ends.
May 30, Friday,	Holiday, Memorial Day.
May 31, Saturday,	Senior examinations begin.
June 7, Saturday,	Non-senior examinations begin.
June 14–18, Saturday–Wednesday,	Commencement.
June 19–21, Thursday–Saturday,	Entrance examinations.
September 3–6, Wednesday–Saturday,	Entrance examinations.
September 10, Wednesday, 1.30 P.M.,	First semester begins; chapel.
October 13, Monday forenoon,	Half holiday, observance of Columbus Day.
November 26–December 1, Wednesday, 1 P.M.–Monday, 1.10 P.M., chapel,	Thanksgiving recess.
December 19, Friday, 6 P.M.,	Winter recess begins.

1914.

January 5, Monday, 1.10 P.M.,	Winter recess ends; chapel.
January 23, Friday,	Semester examinations begin.
February 2, Monday, 1.10 P.M.,	Second semester begins; chapel.
February 23, Monday forenoon,	Half holiday, observance of Washington's Birthday.
March 27, Friday, 6 P.M.,	Spring recess begins.
April 6, Monday, 1.10 P.M.,	Spring recess ends.
April 20, Monday forenoon,	Half holiday, observance of Patriots' Day.
June 1, Monday,	Senior examinations begin.
June 6, Saturday,	Non-senior examinations begin.
June 13–June 17, Saturday–Wednesday,	Commencement.
June 18–20, Thursday–Saturday,	Entrance examinations.

MASSACHUSETTS AGRICULTURAL COLLEGE.

HISTORY. — The Massachusetts Agricultural College was among the first of those organized under the national land grant act of 1862. This act granted public lands to the several States and Territories, the funds realized from the sale of which should be used to establish colleges of agriculture and mechanics arts; the bill was framed by the late Senator Justin Smith Morrill of Vermont. The Legislature of Massachusetts has granted money for the erection of nearly all the buildings now on the grounds, and makes annual appropriations for the maintenance of the college.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to its first class of students. At that time four buildings had been erected, and there were four regular instructors employed by the institution. In 1882 the State located its agricultural experiment station on the grounds of the college. Later, after the federal law was passed granting financial aid to experiment stations, the Massachusetts Agricultural Experiment Station was consolidated with the federal station, and subsequently the whole was incorporated with the college.

COURSES. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The four-years[1] course leads to the degree of bachelor of science, and the graduate school offers advanced courses leading to the degrees of master of science and doctor of philosophy. The winter school of ten weeks, for admission to which no scholastic requirements are made, is held each winter, beginning early in January. There are other short courses at the college, such as the beekeepers' course and summer school. Various forms of extension teaching are carried on away from the college, such as correspondence courses, traveling schools, educational exhibits, lecture courses, demonstrations, etc.

PURPOSE OF THE COLLEGE. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement the term "agricultural vocations" is used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, landscape gardening and forestry. Students are also fitted for positions in institutions designed for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural colleges and high schools, for scientific experts in chemistry, entomology and botany, and for business operations having connection with practical agriculture.

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[1] Twenty-six teaching departments offer instruction in agriculture, horticulture, sciences, the humanities and rural social science. A system of major courses has recently been adopted which permits a student to elect work in 1 of 14 departments and to specialize in that and allied subjects for a period of two years.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences, particularly chemistry, botany and zoölogy, are an essential preparation. Still other students find the course a desirable education, without regard to future occupation. The course of study is designed to give a student a general college education, and in addition to make it possible for him to specialize in any department in which major courses are offered.

LOCATION AND EQUIPMENT. — The agricultural college is located in the town of Amherst. The grounds comprise more than 500 acres, lying about a mile north of the village center. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is about 98 miles from Boston, and may be reached over the Central Massachusetts division of the Boston & Maine Railroad, or by way of the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was then without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college. It was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about one-third of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to the committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, experimentation and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

THE CORPORATION.

MEMBERS OF THE CORPORATION.

	TERM EXPIRES
WILLIAM H. BOWKER of Concord,	1913
GEORGE H. ELLIS of West Newton,	1913
CHARLES E. WARD of Buckland,	1914
ELMER D. HOWE of Marlborough,	1914
NATHANIEL I. BOWDITCH of Framingham,	1915
WILLIAM WHEELER of Concord,	1915
ARTHUR G. POLLARD of Lowell,	1916
CHARLES A. GLEASON of New Braintree,	1916
FRANK GERRETT of Greenfield,	1917
HAROLD L. FROST of Arlington,	1917
CHARLES H. PRESTON of Danvers,	1918
FRANK A. HOSMER of Amherst,	1918
DAVIS R. DEWEY of Cambridge,	1919
M. FAYETTE DICKINSON of Brookline,	1919

MEMBERS EX OFFICIO.

His Excellency Governor EUGENE N. FOSS, *President of the Corporation.*
KENYON L. BUTTERFIELD, *President of the College.*
DAVID SNEDDEN, *State Commissioner of Education.*
J. LEWIS ELLSWORTH, *Secretary of the State Board of Agriculture.*

OFFICERS OF THE CORPORATION.

His Excellency Governor EUGENE N. FOSS of Boston, *President.*
CHARLES A. GLEASON of New Braintree, *Vice-President.*
J. LEWIS ELLSWORTH of Worcester, *Secretary.*
FRED C. KENNEY of Amherst, *Treasurer.*
CHARLES A. GLEASON of New Braintree, *Auditor.*

STANDING COMMITTEES OF THE CORPORATION.[1]

Committee on Finance.

CHARLES A. GLEASON, *Chairman.*
GEORGE H. ELLIS.
NATHANIEL I. BOWDITCH.
ARTHUR G. POLLARD.
CHARLES E. WARD.
FRANK A. HOSMER.

Committee on Course of Study and Faculty.

WILLIAM WHEELER, *Chairman.*
WILLIAM H. BOWKER.
M. FAYETTE DICKINSON.
DAVID SNEDDEN.
ELMER D. HOWE.
DAVIS R. DEWEY.
FRANK A. HOSMER.

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[1] The president of the college is *ex officio* member and secretary of standing committees.

Committee on Farm.

Nathaniel I. Bowditch, *Chairman.*
Frank Gerrett.
Charles A. Gleason.
George H. Ellis.

Committee on Horticulture.

J. Lewis Ellsworth, *Chairman.*
Davis R. Dewey.
Elmer D. Howe.
Harold L. Frost.

Committee on Experiment Department.[1]

Charles H. Preston, *Chairman.*
J. Lewis Ellsworth.
Arthur G. Pollard.
Charles E. Ward.
Harold L. Frost.

Committee on Buildings and Arrangement of Grounds.

William H. Bowker, *Chairman.*
William Wheeler.
Frank Gerrett.
M. Fayette Dickinson.
Charles H. Preston.

Examining Committee of Overseers from the State Board of Agriculture.

John Bursley of West Barnstable.
Frank P. Newkirk of Easthampton.
William E. Patrick of Warren.
John J. Erwin of Wayland.
R. Henry Race of North Egremont.

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[1] The director of the experiment station is a member of the committee on experiment department, without vote.

Officers of the Institution.

[The names of the faculty are arranged in groups according to rank. Within these groups, the order depends upon seniority of service in the college, not upon seniority of appointment to the position now held.]

THE FACULTY.

Kenyon L. Butterfield, A.M., LL.D., ... President's House.
President of the College, and Head of Division of Rural Social Science.

George F. Mills, A.M., ... 46 Amity Street.
Dean of the College and Professor of Languages and Literature.

Charles H. Fernald, Ph.D., ... 3 Hallock Street.
Honorary Director of the Graduate School.

William P. Brooks,[1] Ph.D., ... – –
Director of the Experiment Station and Lecturer on Soil Fertility.

William D. Hurd, M.Agr., ... 82 Pleasant Street.
Director of the Extension Service.

Charles E. Marshall, Ph.D., ... Sunset Avenue.
Director of Graduate School and Professor of Microbiology.

Frank A. Waugh, M.Sc., ... Massachusetts Agricultural College.
Head of Division of Horticulture and Professor of Landscape Gardening.

James A. Foord, M.Sc., ... 56 Lincoln Avenue.
Head of Division of Agriculture and Professor of Farm Administration.

Robert J. Sprague, Ph.D., ... Mount Pleasant.
Head of Division of the Humanities and Professor of Economics and Sociology.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Goessmann Professor of Chemistry.

Charles Wellington, Ph.D., ... 14 Maple Avenue.
Professor of Chemistry.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Professor of Veterinary Science, Chairman of Division of Science.

George E. Stone, Ph.D., ... Mount Pleasant.
Professor of Botany.

Philip B. Hasbrouck, B.Sc., ... 130 Pleasant Street.
Professor of Physics and Registrar of the College.

John E. Ostrander, A.M., C.E., ... 44 North Prospect Street.
Professor of Mathematics and Civil Engineering.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Professor of Entomology.

George C. Martin, C.E., Captain 18th U. S. Infantry, 35 North Prospect Street.
Professor of Military Science and Tactics.

Edward A. White, B.S., ... Mount Pleasant.
Professor of Floriculture.

William R. Hart, A.M., ... 97 Pleasant Street.
Professor of Agricultural Education.

Fred C. Sears, M.Sc., ... Mount Pleasant.
Professor of Pomology.

Fred C. Kenney, ... Mount Pleasant.
Treasurer of the College.

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[1] On leave of absence.

Edward M. Lewis, A.M., ... 34 Amity Street.
Associate Dean and Professor of Literature.

William D. Clark, M.F., ... 25 North Prospect Street.
Professor of Forestry.

Sidney B. Haskell, B.Sc., ... 5 Fearing Street.
Associate Professor of Agronomy.

Robert W. Neal, A.M., ... 7 Woodside Avenue.
Associate Professor of English.

Clarence E. Gordon, Ph.D., ... Nutting Avenue.
Associate Professor of Zoölogy and Geology.

Alexander E. Cance, Ph.D., ... 9 Fearing Street.
Associate Professor of Agricultural Economics.

Joseph S. Chamberlain, Ph.D., ... Mount Pleasant.
Associate Professor of Organic and Agricultural Chemistry.

William P. B. Lockwood, B.Sc.Agr., ... 5 East Pleasant Street.
Associate Professor of Dairying.

Elmer K. Eyerly, A.M., ... 50 Amity Street.
Associate Professor of Rural Sociology.

John A. McLean, A.B., B.Sc.Agr., ... Lincoln Block.
Associate Professor of Animal Husbandry.

John C. Graham, B.Sc.Agr., ... North Amherst.
Associate Professor of Poultry Husbandry.

Guy C. Crampton, Ph.D., ... 86 Pleasant Street.
Associate Professor of Entomology.

Charles A. Peters, Ph.D., ... Sunset Avenue.
Associate Professor of Inorganic and Soil Chemistry.

A. Vincent Osmun, M.Sc., ... North Amherst.
Assistant Professor of Botany.

Edgar L. Ashley, A.M., ... Prospect House.
Assistant Professor of German.

Anderson A. Mackimmie, A.B., ... Nutting Avenue.
Assistant Professor of French.

Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Assistant Professor of Beekeeping.

Curry S. Hicks, B.Sc., ... 8 Allen Street.
Assistant Professor of Physical Education and Hygiene.

Frederick L. Yeaw, B.Sc., ... 17 Fearing Street.
Assistant Professor of Market Gardening.

George S. Gage, Ph.D., ... 27 Sunset Avenue.
Assistant Professor of Animal Pathology.

Ernest Anderson, Ph.D., ... 5 Nutting Avenue.
Assistant Professor of General and Physical Chemistry.

Henry E. Smith, M.A., ... Nutting Avenue.
Assistant Professor of English.

George N. Holcomb, A.B., S.T.B., ... South Pleasant Street.
Lecturer in History.

Frank W. Rane, M.F., ... Boston.
Lecturer in Forestry.

Charles R. Green, B.Agr., ... Mount Pleasant.
Librarian.

C. Robert Duncan, B.Sc., ... 31 North Prospect Street.
Instructor in Mathematics.

Arthur K. Harrison, ... 8 Allen Street.
Instructor in Landscape Gardening.

Chester A. Butman, B.Sc., ... 15 Spring Street.
Instructor in Physics.

Willard A. Wattles, A.M., ... Mount Pleasant.
Instructor in English.

William L. Harmount, A.B., ... 86 Pleasant Street.
Instructor in French.

Elvin L. Quaife, B.Sc.Agr., ... 9 Fearing Street.
Instructor in Animal Husbandry.

William L. Machmer, A.M., Instructor in Mathematics.	Kendrick Place.
Arthur N. Julian, B.A., Instructor in German.	50 Pleasant Street.
Walter W. Chenoweth, M.Sc., Instructor in Pomology.	North Amherst.
Walter E. Prince, B.A., Instructor in English and Public Speaking.	13 Spring Street.
Abbott A. Brown, B.Sc.Agr., Instructor in Poultry Husbandry.	North Amherst.
Elmer M. McDonald, B.Sc., Instructor in Agronomy.	15 Fearing Street.
Samuel Coons, Buttermaker.	56 Pleasant Street.
Helena T. Goessmann, Ph.M., Assistant in English.	44 Amity Street.
Samuel R. Parsons, B.Sc., Assistant in Mathematics and in Military Science.	77 Pleasant Street.
Frederick A. McLaughlin, B.Sc., Assistant in Botany.	Clark Hall.
William J. Fitzmaurice, Assistant in Physical Education.	– –
Robert H. Bogue, B.Sc., Assistant in Chemistry.	17 Phillips Street.

Graduate Assistants.

Irving W. Davis, B.Sc., Assistant in Beekeeping.	96 Pleasant Street.
G. Scott Fowler, B.Sc., Assistant in Chemistry.	15 Phillips Street.
Rupert G. Gates, B.Sc., Assistant in Chemistry.	120 Pleasant Street.
James F. Martin, B.Sc., Assistant in Entomology.	19 South East Street.
Harry A. Noyes, B.Sc., Assistant in Chemistry.	Chemistry Laboratory.
Ralph R. Parker, B.Sc., Assistant in Zoölogy and Geology.	13 Fearing Street.
Raymond G. Smith, B.Sc., Assistant in Botany.	5½ East Pleasant Street.

Other College Officers.

Edwin H. Forristall, M.Sc., Farm Superintendent.	Massachusetts Agricultural College.
Ralph J. Watts, B.Sc., Secretary to the President.	Nutting Avenue.
Harold A. Crane, Cashier.	1 Woodside Avenue.
Newton Wallace, Electrician.	6 Phillips Street.
Percy C. Schroyer, Assistant Engineer.	120 Pleasant Street.
Clarence A. Jewett, Superintendent of Buildings.	112 Pleasant Street.
James Whiting, Foreman, Department of Floriculture.	Hallock Street.
William Chesley, Steward, Dining Hall.	Draper Hall.
John J. Lee, Sergeant, Assistant to the Military Detail.	9 Phillips Street.
Miss Mary E. Caldwell, Bookkeeper.	Draper Hall.

Miss Henrietta Webster, Clerk, Treasurer's Office.	Draper Hall.
Miss Dorothy Mudge, Clerk, Treasurer's Office.	Gaylord Street.
Miss Stella H. Webb, Correspondence Clerk, President's Office.	9 Phillips Street.
Miss Lillian M. Gelinas, Clerk, President's Office.	East Pleasant Street.
Miss Alice Gilbert, Stenographer, Division of Agriculture.	Gaylord Street.
Miss Luliona N. Barker, Stenographer, Division of Agriculture.	9 Phillips Street.
Miss Georgia A. King, Clerk, Registrar's Office.	9 Phillips Street.
Miss Helen V. Gaskill, Stenographer, Division of Floriculture.	105 Main Street.
Miss Lina Fisher, Stenographer, Department of Chemistry.	28 Pleasant Street.
Miss Gladys E. Russell, Stenographer, Division of Horticulture.	Draper Hall.
Miss Virginia Noble, Clerk, Dean's Office.	Draper Hall.
Miss Lorian P. Jefferson, Expert Secretary, Division of Rural Social Science.	Kendrick Place.

THE EXTENSION SERVICE STAFF.

William D. Hurd, M.Agr., Director.	82 Pleasant Street.
Earnest D. Waid, B.Agr., Assistant Director.	Amity Street.
Orion A. Morton, Extension Professor of Agricultural Education.	Mount Pleasant.
Ezra L. Morgan, M.A., Community Field Agent.	Amity Street.
George F. E. Story, B.Sc.Agr., Extension Instructor in Dairying and Animal Husbandry.	10 Allen Street.
Ralph W. Rees, B.Sc., Extension Instructor in Pomology.	17 Fearing Street.
Charles H. White, B.Sc., Field Agent, Worcester County.	North Uxbridge.
Herbert J. Baker, B.Sc., Field Agent in Farm Management.	– –
Arthur T. Dailey, B.Sc., Supervisor of Correspondence Courses.	9 Fearing Street.
Albert W. Doolittle, Field Agent, Barnstable County.	Sandwich.
Miss Mabel R. Case, Clerk to the Director.	Draper Hall.
Miss Hannah Griffin, Clerk.	Draper Hall.

THE EXPERIMENT STATION STAFF.

William P. Brooks,[1] Ph.D., Director.	– –
Fred W. Morse, Ph.D., Acting Director.	40 Pleasant Street.
Joseph B. Lindsey, Ph.D., Vice-Director.	47 Lincoln Avenue.
Fred C. Kenney, Treasurer.	Mount Pleasant.
Charles R. Green, B.Agr., Librarian.	Mount Pleasant.

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[1] On leave of absence.

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Chemist.

Edward B. Holland, M.Sc., ... 28 North Prospect Street.
Associate Chemist, in charge of Research Division.

Fred W. Morse, Ph.D., ... 40 Pleasant Street.
Research Chemist.

Henri D. Haskins, B.Sc., ... Amherst House.
In charge of Fertilizer Division.

Philip H. Smith, M.Sc., ... 102 Main Street.
In charge of Feed and Dairy Division.

Lewell S. Walker, B.Sc., ... 19 Phillips Street.
Assistant.

James C. Reed, B.Sc., ... Nutting Avenue.
Assistant.

Rudolph W. Ruprecht, B.Sc., ... 31 Amity Street.
Assistant.

George R. Pierce, B.Sc., ... 53 Lincoln Avenue.
Assistant.

Carleton P. Jones, B.Sc., ... 30 North Prospect Street.
Assistant.

Joseph T. Howard, ... North Amherst.
Collector.

Harry L. Allen, ... 89 Main Street.
Assistant.

James R. Alcock, ... Massachusetts Agricultural College.
Assistant in Animal Nutrition.

Carlos L. Beals, B.Sc., ... North Amherst.
Assistant.

Department of Agriculture.

William P. Brooks,[1] Ph.D., ... – –
Agriculturist.

Henry J. Franklin, Ph.D., ... East Wareham.
In charge of Cranberry Investigation.

Edwin F. Gaskill, B.Sc., ... North Amherst.
Assistant Agriculturist.

Department of Horticulture.

Frank A. Waugh, M.Sc., ... Massachusetts Agricultural College.
Horticulturist.

Fred C. Sears, M.Sc., ... Mount Pleasant.
Pomologist.

Jacob K. Shaw, Ph.D., ... 1 Allen Street.
Assistant Horticulturist.

Department of Botany and Vegetable Pathology.

George E. Stone, Ph.D., ... Mount Pleasant.
Botanist and Vegetable Pathologist.

George H. Chapman, M.Sc., ... 13 Fearing Street.
Assistant Botanist.

Edward A. Larrabee, B.Sc., ... Clark Hall.
Assistant Botanist.

Department of Entomology.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Entomologist.

Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Apiarist.

Arthur I. Bourne, B.A., ... 12 East Pleasant Street.
Assistant in Entomology.

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[1] On leave of absence.

DEPARTMENT OF VETERINARY SCIENCE.

JAMES B. PAIGE, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Veterinarian.

DEPARTMENT OF METEOROLOGY.

JOHN E. OSTRANDER, A.M., C.E., ... 35 North Prospect Street.
Meteorologist.
HARRIS W. ANGIER, ... Massachusetts Agricultural College.
Observer.

OTHER OFFICERS OF THE EXPERIMENT STATION.

BENJAMIN G. SOUTHWICK, B.Sc., ... Massachusetts Agricultural College.
Secretary to the Director.
Mrs. LUCIA G. CHURCH, ... 4 Hallock Street.
Stenographer, Director's Office.
Miss F. ETHEL FELTON, ... 9 Phillips Street.
Stenographer, Department of Plant and Animal Chemistry.
Miss BRIDIE O'DONNELL, ... Hadley.
Stenographer, Department of Entomology.
Miss ALICE M. HOWARD, ... North Amherst.
Stenographer, Department of Plant and Animal Chemistry.
Miss JESSIE V. CROCKER, ... Sunderland.
Stenographer, Department of Botany.
Miss GRACE E. GALLOND, ... 28 Pleasant Street.
Stenographer, Director's Office.
Miss MARY R. KINGSBURY, ... 97 Pleasant Street.
Stenographer, Department of Poultry Husbandry.

STANDING COMMITTEES OF THE FACULTY.[1]

1912-13.

CATALOGUE AND OTHER PUBLICATIONS.

Associate Professor NEAL.
  Associate Professor EYERLY.
  Associate Professor CANCE.

COMMENCEMENT.

Professor PAIGE.
  Captain MARTIN.
  Professor WHITE.
  Mr. KENNEY.
  Mr. DUNCAN.
  Mr. PHILIP H. SMITH.[2]

COURSE OF STUDY.

Professor HART.
  Professor WAUGH.
  Professor FOORD.
  Professor OSTRANDER.
  Professor SPRAGUE.
  Associate Professor CHAMBERLAIN.

DISCIPLINE (ADVISORY).

Professor MILLS.
  Professor HASBROUCK.
  Captain MARTIN.
  Professor LEWIS.
  Associate Professor GORDON.
  Assistant Professor MACKIMMIE.

EMPLOYMENT.

Professor SEARS.
  Mr. KENNEY.
  Associate Professor HASKELL.

ENTRANCE EXAMINATIONS AND ADMISSION.

Professor HASBROUCK.
  Associate Professor GRAHAM.
  Assistant Professor OSMUN.
  Assistant Professor ASHLEY.
  Mr. MACHMER.
  Mr. WATTLES.

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[1] The president of the college is ex officio member of each standing committee.

[2] Not a member of the faculty.

GRADUATE SCHOOL.

Director MARSHALL.
    Professor LINDSEY.
    Professor PAIGE.
    Professor STONE.
    Professor FERNALD.
    Professor SEARS.
    Associate Professor GORDON.

LIBRARY.

Professor STONE.
    Professor WELLINGTON.
    Professor MARSHALL.
    Associate Professor CANCE.

PHYSICAL EDUCATION AND ATHLETICS.

Assistant Professor HICKS.
    Director HURD.
    Professor LEWIS.
    Assistant Professor YEAW.

SCHEDULE.

Associate Professor LOCKWOOD.
    Associate Professor NEAL.
    Associate Professor PETERS.

SCHOLARSHIP.

Associate Professor GORDON.
    Professor MILLS.
    Professor HASBROUCK.
    Professor LEWIS.
    Assistant Professor MACKIMMIE.

STUDENT LIFE.

Director HURD.
    Professor LEWIS.
    Associate Professor CHAMBERLAIN.
    Associate Professor MCLEAN.
    Associate Professor HASKELL.
    Assistant Professor MACKIMMIE.
    Assistant Professor HICKS.

UNCLASSIFIED STUDENTS.

Professor WHITE.
    Associate Professor LOCKWOOD.
    Associate Professor PETERS.

THE COLLEGE.

ADMISSION.

A. Application for Admission.

Correspondence about admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege on or before June 1 of the year in which examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. Modes of Admission.

Students are admitted to the freshman class either upon *certificate* or upon *examination.* No *diploma* from a secondary school will be considered.

Certificates. — The entrance requirements may be met by certification in any of the following ways: —

1. By presenting certificate from a school approved for such privilege by this college.
2. By presenting certificate from any school approved by the college entrance examination boards.
3. By presenting the customary credentials from the Board of Regents of the State of New York for any of the subjects of the entrance requirements.

Certificates must present not less than seven of the necessary fourteen credits in all. Those subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

Examinations. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.[1]

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[1] *Entrance with Condition in English.* — Under the rule permitting entrance conditions of not more than two units of the preparatory subjects applicants may be admitted, upon examination, with a condition in English, provided that they show, upon examination, satisfactory preparation in work entitling them to a ranking of 60 or higher.

Students so admitted, must, to remove the condition, pass an examination covering the regular 3-units requirement.

Places of Examination. — Examinations for admission to the college are held as follows: —

In June of each year: in Amherst, in the building of the Department of Physics, Massachusetts Agricultural College; in Boston, in the College of Liberal Arts of Boston University, Boylston Street, corner of Exeter; in Worcester, in Horticultural Hall.

In September, examinations will be held in Amherst only.

Schedule for Entrance Examinations, June 19–21, inclusive, 1913. — The examinations in June will follow this schedule: —

First Day.

7.45 A.M.	Registration.[1]
8 A.M.	Plane geometry.
10 A.M.	Chemistry.
11.30 A.M.	Botany.
2 P.M.	Algebra.
3.30 P.M.	Physics.

Second Day.

8 A.M.	Required English.
11 A.M.	Solid geometry.
2 P.M.	History, required and elective.

Third Day.

8 A.M.	French, German, required and elective.
1 P.M.	Latin A and B and all one-half electives, except those already noted.

Schedule for Entrance Examinations in September. — In September, 1913, the examinations will be given September 3–6, inclusive, and will follow the order indicated below: —

First Day.

1 P.M.	Registration.
1.15–5 P.M.	Greek A and B.

Second Day.

8 A.M.	Plane geometry.
10 A.M.	Chemistry.
11.30 A.M.	Botany.
2 P.M.	Algebra.
3.30 P.M.	Physics.
4.30 P.M.	Elective English.

Third Day.

8 A.M.	Required English.
11 A.M.	Solid geometry, agriculture.
2 P.M.	History, required and elective.

Fourth Day.

8 A.M.	French, German, required and elective.
1 P.M.	Latin A and B and all one-half credit electives, except those already noted.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-years course in a high school or its equivalent, and are stated in terms of units. The term unit means the equivalent of four or five recitations a week for a school year. Neither more nor less credit will be given in any subject than is indicated in the table below. Fourteen units must be offered for admission, of which eight and one-half are required and five and one-half are elective.

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[1] Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

(*a*) The following eight and one-half units are required: —

Language.

English,	3
French or German,	2

History and Civics.

History (elective),	1
(*a*) Ancient history.	
(*b*) Medieval and modern history.	
(*c*) English history.	
(*d*) General history.	
(*e*) United States history and civics.	

Mathematics.

Algebra, through progressions,	1½
Plane geometry,	1

(*b*) In addition to the requirements under (*a*), five and one-half units must be offered from the following-named elective subjects. Not more than four of those subjects in which the credit sought is one-half unit will be accepted.

Language.

English in addition to requirements,	1
French in addition to requirements,	2 or 1 [1]
German in addition to requirements,	2 or 1 [1]
Greek,	2 or 3
Latin,	2 or 3

History.

In addition to requirements,	1, 2, or 3

Mathematics, and Other Sciences.

Solid geometry,	½
Trigonometry,	½
Chemistry,	1
Physiography,	½
Physiology,	½
Agriculture,[2]	½ or 1
Botany,[2]	½ or 1
Geology,[2]	½
Physics,[2]	1
Zoölogy,[2]	½
Commercial geography,[3]	½
Drawing,[3]	½
Manual training,[3]	½ or 1

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[1] If but one elective unit be offered, it must be in the same language as that offered to meet the two-year language requirement.

[2] Note-book required as part of preparation will be credited as part of the examination.

[3] Certification necessary in these subjects; no examinations given.

PRESENTATION OF NOTE-BOOKS. — The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 2, page 25).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificate should not present note-books; but their certificate must state that note-books have been satisfactorily completed.

D. STATEMENT OF PREPARATION REQUIRED FOR ADMISSION.

In some cases the requirements of the College Entrance Examination Board are here mentioned. A pamphlet containing detailed explanation of these requirements can be had of the Board for 10 cents. Address substation 84, New York City.

AGRICULTURE.[1] — Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and kinds of work accomplished and of the text-books used. The examination will be based somewhat upon this information; but it will call for not less than one-half year of creditable work of high school grade. The examination in agriculture will be given in September only.

BOTANY. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Steven's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit; and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

CHEMISTRY. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements, some of the experiments being quantitative. The keeping of a note-book is required.

MATHEMATICS. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations;

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[1] Examination given in September only.

the binomial theorem for positive integral exponents, the formulas for the nth term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

PHYSICS. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work should consist of both class-room work and laboratory practice. The work covered in the class room should be equal to that outlined in Hall & Bergen's "Text-book of Physics;" the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

PHYSIOLOGY. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body: Briefer Course."

ZOÖLOGY, PHYSIOGRAPHY, GEOLOGY. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis's "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present note-books, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

HISTORY. — The required unit must be offered in either ancient history, medieval and modern history, English history, general history, or United

States history and civics. Either one, two or three elective units in any of the historical subjects here named may be offered, provided that such units may not be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on an outline map.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers, in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

English. — For 1913, 1914: —

English Grammar and Composition. — Command of correct and clear English (spoken or written) requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, paragraphs, and the different kinds of whole composition, including letter writing, should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise narration, description and easy exposition and argument based upon simple outlines. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

Literature. — Ability to read with accuracy, intelligence and appreciation is sought through study of books included in two lists, headed respectively "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud, and encouraged to commit to memory some of the more notable passages, both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads, and with their place in literary history.

(*a*) Reading: The aim of this course is to foster in the student the habit of intelligent reading, and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from which at least ten units (each unit being set off by semicolons) are to be selected, two from each group: —

I. The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission if desired, of books XI., XIII., XIV., XV., XVII., XXI.; Virgil's "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any unit of this group a unit from any other group may be substituted.

II. Shakspere's "Merchant of Venice;" "Midsummer Night's Dream;" "As You Like It;" "Twelfth Night;" "Henry the Fifth;" "Julius Cæsar."

III. Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" either Scott's "Ivanhoe" or "Quentin Durward;" Hawthorne's "House of the Seven Gables;" either Dickens's "David Copperfield" or "A Tale of Two Cities;" Thackeray's "Henry Esmond;" Mrs. Gaskell's "Cranford;" George Eliot's "Silas Marner;" Stevenson's "Treasure Island."

IV. Bunyan's "Pilgrim's Progress," Part I.; "The Sir Roger de Coverley Papers" in "The Spectator;" Franklin's "Autobiography" (condensed); Irving's "Sketch Book," Macaulay's "Essays on Lord Clive" and "Warren Hastings;" Thackeray's "English Humourists;" selections from Lincoln, including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address and the letter to Horace Greeley, along with a brief memoir or estimate; Parkman's "Oregon Trail;" either Thoreau's "Walden," or Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge;" "A Liberal Education" and "A Piece of Chalk;" Stevenson's "Inland Voyage" and "Travels with a Donkey."

V. Palgrave's "Golden Treasury" (first series), books II. and III., with especial attention to Dryden, Collins, Gray, Cowper and Burns; Gray's "Elegy in a Country Churchyard" and Goldsmith's "Deserted Village;" Coleridge's "Ancient Mariner" and Lowell's "Vision of Sir Launfal;" Scott's "Lady of the Lake;" Byron's "Childe Harold," Canto IV., and "Prisoner of Chillon;" Palgrave's "Golden Treasury" (first series), book IV., with especial attention to Wordsworth, Keats and Shelley; Poe's "Raven," Longfellow's "Courtship of Miles Standish," and Whittier's "Snow Bound;" Macaulay's "Lays of Ancient Rome" and Arnold's "Sohrab and Rustum;" Tennyson's "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last Duchess," "Up at a Villa — Down in the City."

(*b*) Study: This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. For this close reading are provided a play, a group of poems, an oration and an essay, as follows: —

Shakspere's "Macbeth;" Milton's "L'Allegro," "Il Penseroso" and "Comus;" either Burke's "Speech on Conciliation with America," or both Washington's "Farewell Address" and Webster's "First Bunker Hill Oration;" either Macaulay's "Life of Johnson," or Carlyle's "Essay on Burns."

Examination. — However accurate in subject-matter, no paper will be deemed satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which may be taken as a preliminary, and the other as a final.

The first part of the examination will be based upon ten units chosen, in accordance with the plan described earlier, from the lists headed reading; and it may include also questions upon grammar and the simpler principles of rhetoric, and short compositions upon topics drawn from the student's general knowledge or experience. On the books prescribed for reading, the form of the examination will usually be the writing of short paragraphs on several topics which the candidate may choose out of a considerable number. These topics will involve such knowledge and appreciation of plot, character-development and other qualities of style and treatment as may be fairly expected of boys and girls. In grammar and rhetoric, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors.

The second part of the examination will include composition and these books comprised in the list headed study. The test in composition will consist of one essay or more, developing a theme through several paragraphs; the subjects will be drawn from the books prescribed for study, from the candidate's other studies and from his personal knowledge and experiences quite apart from reading. For this purpose the examiner will provide several subjects from which the candidate may make his own selections. The test on the books prescribed for study will consist of questions upon their content, form and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their other works, and the periods of literary history to which they belong.

ENGLISH, ELECTIVE.[1] — To secure a fourth entrance credit in English, the applicant should do (*a*) the full equivalent of three years' work (required English), and also (*b*) the full equivalent of a fourth year's work. Applicants not certified with a fourth entrance credit will be examined, provided that the applicant, on or before June 1, notify the Department of English of his intention to take the examination, and supply thereafter the information needed by the department to prepare the examination questions. The information blanks will be forwarded by the Department of English upon receipt of the notice.

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[1] Examination given in September only.

Subjects accepted. — The applicant may offer (*a*) any one of the subjects stated hereunder, or (*b*) any two of these subjects in combination.

(*a*) History of American literature.

(*b*) History of English literature (or lives of the great authors).

(*c*) Classics *other than those read to meet the three-credit requirement.*

(*d*) Advanced composition.

(*e*) History of the English language.

(*f*) Advanced high school grammar.

Advanced Standing in College. — Whether advanced standing shall be given applicants entering with a fourth credit in English will be determined by consideration of each case individually. Much weight is given to the ability of the student to express himself correctly and clearly, to think clearly, and to grasp the meaning of printed language. A special examination will be given in the opening week of college, notice of which will be posted on the English bulletin board, for freshmen who wish to apply for advanced standing.

Presentation of Note-books and Themes. — Applicants for examination, either for fourth-unit credit or for advanced standing, are advised to present the note-books, themes, etc., prepared by them in the preparatory school, as an aid toward determining their proficiency.

For 1915–19 inclusive: —

The requirements for entrance to the Massachusetts Agricultural College continue to be those of the National Conference on Uniform Entrance Requirements in English (for detailed statement governing 1915–19, apply to the College Entrance Examination Board).

Attention is called to two recommendations of the National Conference made in the official statement of requirements for 1915–19; namely: —

1. That colleges so desiring may set an examination requiring no prescribed books, but testing the same general kind of preparation as that indicated in the standard requirements.

2. That individual colleges take such steps as may be found necessary to ascertain whether candidates for entrance possess an adequate equipment in oral English.

These recommendations agree with the policy of the agricultural college, which will, as rapidly as seems expedient, proceed in accordance with them. Schools wishing to present candidates prepared in accordance with the intent of these recommendations will have the co-operation of the college. The college understands this intent to be the development of the pupil's powers of thought, understanding and expression; the test to be not merely a test of memory, but even more a test of ability, to be shown by dealing with new problems calling for the application of his previously gained knowledge and skill.

The list of books prescribed for 1915–19 here follows: —

(A) *Reading*: With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from each of which at least two selections are to be made, except as otherwise provided under Group I: —

Group I. Classics in Translation. — The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther;

the "Odyssey," with the omission, if desired, of books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of books XI., XIII., XIV., XV., XVII., XXI.; the "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellency.

For any selection from this group a selection from any other group may be substituted.

Group II. Shakspere. — "Midsummer Night's Dream;" "Merchant of Venice;" "As You Like It;" "Twelfth Night;" "The Tempest;" "Romeo and Juliet;" "King John;" "Richard II.;" "Richard III.;" "Henry V.;" "Coriolanus;" "Julius Cæsar;"[1] "Macbeth;"[1] "Hamlet."[1]

Group III. Prose Fiction. — Malory's "Morte d'Arthur" (about 100 pages); Bunyan's "Pilgrim's Progress," Part I.; Swift's "Gulliver's Travels" (voyages to Lilliput and to Brobdingnag); Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" Frances Burney's "Evelina;" Scott's novels, any *one*, "Guy Mannering," "Ivanhoe," "Old Mortality," "Quentin Durward," "Rob Roy," or "The Talisman;" Jane Austen's novels, any *one*; Maria Edgeworth's "Castle Rackrent" or "The Absentee;" Dickens's novels, any *one*; Thackeray's novels, any *one*; George Eliot's novels, any *one*; Mrs. Gaskell's "Cranford;" Kingsley's "Westward Ho!" or "Hereward the Wake;" Reade's "The Cloister and the Hearth;" Blackmore's "Lorna Doone;" Hughes's "Tom Brown's School Days;" Stevensons "Treasure Island," "Kidnapped" or "Master of Ballantrae;" Cooper's novels, any *one*; Poe's "Selected Tales;" Hawthorne's "The House of the Seven Gables," "Twice Told Tales" or "Mosses from an Old Manse;" a collection of short stories by various standard writers.

Group IV. Essays, Biography, etc. — Addison and Steele's "The Sir Roger de Coverley Papers" or selections from the "Tattler" and "Spectator" (about 200 pages); selections from Boswell's "Life of Johnson" (about 200 pages); Franklin's "Autobiography;" Irving's selections from the "Sketch Book" (about 200 pages) or "Life of Goldsmith;" Southey's "Life of Nelson;" Lamb's selections from the "Essays of Elia" (about 100 pages); Lockhart's selections from the "Life of Scott" (about 200 pages); Thackeray's "Lectures on Swift, Addison, and Steele in the English Humorists;" Macaulay: any one of the following of Macaulay's essays: "Lord Clive," "Warren Hastings," "Milton," "Addison," "Goldsmith," "Frederic the Great," "Madame d'Arblay;" Trevelyan's selections from the "Life of Macaulay" (about 200 pages); Ruskin's "Sesame and Lilies" or "Selections" (about 150 pages); Dana's "Two Years before the Mast;" Lincoln's "Selections," including at least the two "Inaugurals," the "Speeches in Independence Hall and at Gettysburg," the "Last Public Address," the "Letter to Horace Greeley," together with a brief memoir or estimate of Lincoln; Parkman's "The Oregon Trail;" Thoreau's "Walden;" Lowell's "Selected Essays" (about 150 pages); Holmes's "The Autocrat of the Breakfast Table;" Stevenson's "An Inland Voyage" and "Travels with a Donkey;" Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge," "A Liberal

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[1] If not chosen for study under B.

Education" and "A Piece of Chalk;" a collection of "Essays" by Bacon, Lamb, De Quincey, Hazlitt, Emerson, and later writers; a collection of "Letters" by various standard writers.

Group V. Poetry. — Palgrave's "Golden Treasury" (first series), books II. and III., with special attention to Dryden, Collins, Gray, Cowper and Burns; Palgrave's "Golden Treasury" (first series), Book IV., with special attention to Wordsworth, Keats and Shelley (if not chosen for study under B); Goldsmith's "The Traveller" and "The Deserted Village;" Pope's "The Rape of the Lock;" a collection of English and Scottish ballads, as, for example, some "Robin Hood" ballads, "The Battle of Otterburn," "King Estmere," "Young Beichan," "Bewick and Grahame," "Sir Patrick Spens," and a selection from later ballads; Coleridge's "The Ancient Mariner," "Christabel" and "Kubla Khan;" Byron's "Childe Harold," Canto III. or IV., and "The Prisoner of Chillon;" Scott's "The Lady of the Lake" or "Marmion;" Macaulay's "The Lays of Ancient Rome," "The Battle of Naseby," "The Armada," "Ivry;" Tennyson's "The Princess" or "Gareth and Lynette," "Lancelot and Elaine," and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last Duchess," "Up at a Villa — Down in the City," "The Italian in England," "The Patriot," "The Pied Piper," "De Gustibus," "Instans Tyrannus;" Arnold's "Sohrab and Rustum" and "The Forsaken Merman;" selections from American poetry, with special attention to Poe, Lowell, Longfellow and Whittier.

(B) *Study:* This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. The books provided for study are arranged in four groups, from each of which one selection is to be made.

Group I. Drama. — Shakspere's "Julius Cæsar," "Macbeth," "Hamlet."

Group II. Poetry. — Milton's "L'Allegro," "Il Penseroso" and either "Comus" or "Lycidas;" Tennyson's "The Coming of Arthur," "The Holy Grail" and "The Passing of Arthur;" the selections from Wordsworth, Keats and Shelley in Book IV. of Palgrave's "Golden Treasury" (first series).

Group III. Oratory. — Burke's "Speech on Conciliation with America;" Macaulay's "Speech on Copyright" and Lincoln's "Speech at Cooper Union;" Washington's "Farewell Address" and Webster's "First Bunker Hill Oration."

Group IV. Essays. — Carlyle's "Essay on Burns," with a selection from Burns's "Poems;" Macaulay's "Life of Johnson;" Emerson's "Essay on Manners."

French. — The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a single credit unit in French as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For two credit units, the work described as "intermediate" and "advanced" is expected.

German. — The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).

Third and fourth year German (elective subjects for admission). — For a single credit unit in German as an elective subject for entrance, when required units have been offered in German, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For two credit units, the work described as "intermediate" and "advanced" is expected.

Greek.[1] — Greek will receive credit as an elective requirement upon either examination or certification, as follows: —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first four books of Xenophon's "Anabasis," and (*b*) the translation of passages of Attic prose at sight.

B. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages from the first six books of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the form and constructions of the passages.

Latin. — Latin will receive credit as an elective requirement upon either examination or certification, as follows: —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

B. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages selected from either books I. to VI. of Virgil's "Æneid," or six orations of Cicero, including those against Catiline; and (*b*) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," books I. to IV.

Commercial Geography. — Preparation should be given in a course equivalent to that laid down in Adam's "Commercial Geography," Trotter's "Geography of Commerce," or a similar work.

Drawing. — Applicants may offer either freehand or mechanical drawing, or both. They must be able to make an accurate freehand sketch, in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable them to draw correctly a simple geometric model from memory; or, if they present mechanical drawing, they must have considerable working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented see "Manual Training."

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[1] Examination given in September only.

Manual Training. — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

E. Admission to Advanced Standing.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. Other Information about Entrance.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)
2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.
3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed. No candidate deficient in both algebra and plane geometry will be admitted.
4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination, in the week following the Thanksgiving recess. (2) Second entrance condition examination, in the sixteenth week of the first semester.
5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.
6. Examinations in part of the subjects required for entrance may be taken one year before entering college.
7. For information concerning expenses, scholarships, etc., see "General Information."
8. For information concerning admission to short courses see "Short Courses."
9. All requests for information concerning admission of unclassified students should be addressed to Prof. E. A. White, chairman of committee on unclassified students.

G. Unclassified Students.

Students not candidates for a degree (unclassified students) are admitted under the following provisions: —

1. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-years high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

2. No applicant under twenty-one years of age will be admitted as an unclassified student.

3. Each unclassified student must take from the regular courses a minimum of twelve credit hours a week.

4. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

5. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 75 per cent. An unclassified student who passes in less than two-thirds of his work will be dropped from college.

6. All unclassified students are subject to the supervision of a special committee.

7. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than four semesters without the special permission of the faculty.

8. Unclassified students are subject to the regulations applying to classified students.

9. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

10. No unclassified student shall be allowed to participate in any intercollegiate contests.

COURSES OF INSTRUCTION.

A. TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.

[The figures indicate the number of credit hours a week. For details, see the descriptions of courses.]

FRESHMAN YEAR.

First Semester.

[All work required.]

Chemistry,	3
Algebra,	3
Solid Geometry,[1]	2
English,	4
Public Speaking (at option of instructor),	1
French or German,[2]	4
Drill,	1
Hygiene,	1
College Life (attendance without credit).	
	18 or 19

Second Semester.

[All work required.]

Animal Husbandry,	2
Chemistry,	3
Trigonometry,	3
Algebra,	2
English,	4
Public Speaking (if not taken in semester one),	1
French or German,	4
Drill,	1
Physical Education,	1
	20 or 21

SOPHOMORE YEAR.

First Semester.

[All work required.]

Agronomy,	3
Physics,	5
Zoölogy,	3
English,	2
French or German,	3
Tactics,	1
Drill,	1
	18

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[1] To be taken in course when not offered for entrance.

[2] Students may continue in college the language that they present for admission, or they may take the other; but they must continue whichever language they so elect until the end of the first semester of the sophomore year. Eleven college credits are required in this language.

Second Semester.

[All courses under "Required," with any two of those under "Elective."]

[Required.]

Elementary Horticulture,	2
Botany,	4
English,	2
Agricultural Industry,	3
Drill,	1
Tactics,	1
Physical Education,	1
	14

[Elective.]

French or German, Animal Husbandry, Geology, Physics, Chemistry, Surveying,	Each 3 hours. Any two,	6
		20

B. MAJORS: JUNIOR AND SENIOR YEARS.

General Statement.

A major consists of 30 hours of correlated work, to be arranged by the student and an instructor called the adviser. The special provisions applying to the class of 1913 are given in the footnote.[1]

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their department. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules.

Rule 1. *Election.* — Each student, in the second semester of his sophomore year, shall elect a major subject from the list of majors given below; and this major shall consist of 30 credit hours of correlated work.

Rule 2. *Minimum Credits.* — The minimum number of credits for the junior and senior years shall be 65, inclusive of Military Drill and Physical Education.

Rule 3. *Maximum Credits.* — The maximum number of credits for any semester of the junior or senior year shall be 21.

Rule 4. *Humanities and Rural Social Science.* — A minimum of 15 credit hours in the Divisions of the Humanities and Rural Social Science shall be required of all students during their junior and senior years, with the following restriction: that a minimum of 3 credit hours will be required in each of the divisions.

Rule 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 30 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.* — Each student is required to take 30 hours in his major and also 15 hours in the Divisions of the Humanities and Rural Social Science, making a total of 45 hours. He is allowed free choice for the remaining part of his required hours, this remainder amounting to 15 hours minimum for the two years, or 35 hours maximum.

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[1] Since it will not be possible for the class of 1913 to conform fully with the regulations concerning majors given above, the following regulations will apply to them in making their elections: —

As stated below, the minimum semester credits will be 15 hours, the maximum 21 hours, and the members of the class of 1913 will fill out their elective cards with these facts in mind. For the class of 1913 the required work after the sophomore year is to be counted as follows: —

5 credits in the junior year in Military Science and Physical Education.
3 credits in Economics 1.
3 credits in English, in other subjects in the Humanities, or in Rural Social Science.

RULE 7. *Registration.* — No upper classman shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office on June 5.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the year and will countersign the same.

(3) Each course card must be filled out, giving the name of student, with his college address, also the name of parent or guardian, with the home address. When the elections have been entered on this card, and the balance of hours added by the student, the card must be returned to the registrar not later than June 16.

RULE 8. *Changes.* — Applications for changes may be made to the dean in writing at any time, and, when approved by him and by the committee on scholarship, become operative at the beginning of the semester following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

LIST OF MAJORS.

Agriculture.

Prof. JAMES A. FOORD, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 6,	3
Animal Husbandry 3,	3
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 9,	3
Dairying 1,	3
Dairying 2,	3
Farm Administration 3,	3
Farm Administration 4,	3
Veterinary Science 1,	3
	31

Agronomy.

Associate Prof. SIDNEY B. HASKELL, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 4,	3
Agronomy 5,	3
Agronomy 6,	3
Agronomy 8,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Farm Administration 4,	3
Chemistry 7,	3
Chemistry 8,	3
	30

Animal Husbandry.

Associate Prof. J. ALLAN MCLEAN, Adviser.

Course.	Credit.
Agronomy 3,	3
Animal Husbandry 3,	3
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 10,	3
Animal Husbandry 11,	2
Dairying 1,	3
Farm Administration 3,	3
Farm Administration 4,	3
	29

Dairying.

Associate Prof. WILLIAM P. B. LOCKWOOD, Adviser.

Course.	Credit.
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 11,	2
Dairying 1,	3
Dairying 2,	3
Dairying 3,	3
Dairying 4,	3
Farm Administration 3,	3
Farm Administration 4,	3
	29

Poultry Husbandry.

Associate Prof. JOHN C. GRAHAM, Adviser.

Course.	Credit.
Poultry Husbandry 1,	2
Poultry Husbandry 2,	2
Poultry Husbandry 3,	1
Poultry Husbandry 4,	1-3
Poultry Husbandry 5,	1
Poultry Husbandry 6,	3
Poultry Husbandry 7,	3
Poultry Husbandry 9,	3
Pomology 1,	3
Agronomy 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Veterinary Science 1,	3
	31

General Horticulture.

Prof. FRANK A. WAUGH, Adviser.

This major will consist of courses selected from the Departments of Pomology, Floriculture, Market Gardening, Landscape Gardening and Forestry, to suit the particular needs of the student. In special cases, courses from the Department of Agronomy will also be counted toward the major in general horticulture.

Floriculture.

Prof. Edward A. White, Adviser.

Course.	Credit.
Floriculture 1,	4
Floriculture 2,	4
Floriculture 3,	3
Floriculture 4,	3
Horticulture 3,	3
Horticulture 4,	3
Entomology 1,	3
Market Gardening 2,	3
Botany 2,	4
	30

Note. — Horticulture 3 and 4 is a junior subject, but to balance the work for the two years it would be better for the floricultural students to take the course in the senior year.

Forestry.

Prof. William D. Clark, Adviser.

Course.	Credit.
Forestry 1,	3
Forestry 2,	3
Forestry 3,	3
Forestry 4,	3
Forestry 5,	2
Forestry 6,	2
Entomology 5,	3
Horticulture 3,	3
Horticulture 4,	3
Botany 13,	4
	29

Landscape Gardening.

Prof. Frank A. Waugh, Adviser.

Course.	Credit.
Landscape Gardening 1,	3
Landscape Gardening 2,	3
Landscape Gardening 3,	3
Landscape Gardening 4,	3
Landscape Gardening 5,	2
Landscape Gardening 6,	2
Landscape Gardening 7,	3
Landscape Gardening 8,	3
Drawing 1,	3
Drawing 2,	3
Horticulture 3,	3
	31

Landscape Gardening 6 will probably be given quite differently in alternate years, and thus should be open to *both* juniors and seniors.

Courses for juniors *only:* Landscape Gardening 1 and 2, Drawing 1 and 2.

Courses for seniors and graduates *only:* Landscape Gardening 7 and 8.

Courses open to juniors and seniors, both if possible: Horticulture 3 and 4 and possibly Landscape Gardening 3 and 4.

This grouping of subjects is offered only as an example. Other groupings may be approved by the adviser, but such other groupings must be subject to the class schedule.

Pomology.

Prof. FRED C. SEARS, Adviser.

Course.	Credit.
Pomology 1,	3
Pomology 2,	3
Pomology 3,	3
Pomology 4,	3
Botany 5,	2
Botany 7,	5
Agronomy 6,	3
Farm Administration 3,	3
Farm Administration 4,	3
Entomology 2,	3
	31

Agricultural Chemistry.

Associate Prof. CHARLES A. PETERS, Adviser.

Course.	Credit.
Chemistry 5,	5
Chemistry 6,	5
Chemistry 9,	5
Chemistry 10,	5
Chemistry 11,	5
Chemistry 12, 14 or 16,	5
Chemistry 13,	3
Chemistry 15,	3
Chemistry 18,	2
	38

The major will consist of 30 credit hours selected from this list. The student will be advised concerning other subjects suited to be taken in connection with Chemistry.

Economic Entomology.

Prof. HENRY T. FERNALD, Adviser.

Course.	Credit.
Entomology 1,	3
Entomology 2,	2
Entomology 3,	4
Entomology 4,	4
Entomology 5,	3
Entomology 8,	3
Botany 3,	4
Botany 4,	2
Zoölogy 3,	3
Zoölogy 4,	3
	31

A major in Economic Entomology does not necessarily include all the subjects given in this list, but may be varied to some extent, in accordance with the future plans of the student, other modifications being permissible.

Plant Physiology and Pathology.

Prof. George E. Stone, Adviser.

Course.	Credit.
Botany 3,	4
Botany 4,	2
Botany 10,	4 or 5
Botany 14,	4
Chemistry 5,	5
Chemistry 6,	5
Entomology 1,	3
Entomology 2,	2
	29 or 30

Agricultural Education.

Prof. William R. Hart, Adviser.

Course.	Credit.
Agricultural Education 1,	3
Agricultural Education 2,	3
Agricultural Education 3,	2
Agricultural Education 4,	3
Agronomy 3,	3
Dairying 5,	2
Farm Administration 3,	3
Poultry Husbandry 1,	2
Market Gardening 2, Agronomy 5,	3
Botany 5,	2
Pomology 1,	3
	29

Some substitutions of other technical courses for some of the technical courses above mentioned will be made to meet the needs of individual students.

SUMMARY.

There are four preliminary steps which a student should take in arranging for his major work.

1. Select a major.

2. Confer with major adviser for arrangement of courses, the plan to be approved by adviser in accordance with Rule 5 previously stated.

3. Select courses covering the four semesters of the junior and senior years in such a way that a minimum of 15 credits will be taken in the two Divisions, the Humanities and Rural Social Science; the distribution of all but 3 of these credits may be decided by the student.

4. Choose other courses so that the total number of credits for any semester shall be not less than 16 nor more than 21. (See Rules 2 and 3.)

C. UNDERGRADUATE COURSES.

[All courses given in the first semester bear odd numbers; all given in the second semester bear even numbers. Studies are pursued in courses, "course" implying the study given a subject within one semester, without regard to the total number of hours or to the number of credits. The special mention of certain courses as prerequisite to other courses does not imply that no courses but those so mentioned are "preliminary or preparatory" within the meaning of the Book of Rules.]

DIVISION OF AGRICULTURE.

Professor Foord.

AGRONOMY.

Associate Professor Haskell, Dr. Brooks, Mr. McDonald.

Required Course.

1. Soils and Fertilizers. — A study of the formation, classification and physical and chemical properties of soils. This is followed by study of methods of soil improvement and of maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments. Prerequisites, Chemistry 1 and 2. Sophomores; 3 hours. Credit, 3.

Associate Professor Haskell and Mr. McDonald.

Elective Courses.

3. Field and Forage Crops. — History, classification, cultivation, harvesting, commercial grading and valuation. The crops studied are the cereal grains, grasses, legumes, forage and root crops suitable to New England conditions. The work includes lecture, laboratory and field study of these various crops. Prerequisites, Agronomy 1 and Botany 2. For juniors primarily; 1 lecture and 2 laboratory periods. Credit, 3.

Mr. McDonald.

4. Advanced Field Crops. — Commercial production of grain, hay and root crops. Lecture, laboratory, and field study of the purity, quality, and vitality of the seed of these crops and the handling, grading and judging of their products. The work offered will not be confined to New England conditions. Prerequisite, Agronomy 3. For juniors primarily; 2 lectures and 1 laboratory period. Credit 3. Mr. McDonald.

5. Advanced Soils. — A field, laboratory and lecture course on soils; their nature, composition, physical qualities, improvement. Field work, as far as the season allows, consists of detailed soil surveys in different parts of the Connecticut valley; this followed by laboratory work on the physical properties of the soil collected, on the effect of fertilizers on the soil, and on the mixing of fertilizers. Prerequisites, Agronomy 1 and Chemistry 1 and 2. For seniors primarily; 1 lecture period and 1 4-hour laboratory period weekly. Credit, 3. Associate Professor Haskell.

6. Drainage and Irrigation. — A field and lecture course on soil improvement, by drainage and irrigation. As a thesis each man is required, after studying an area of wet or swampy land, to present plans and estimates for its reclamation. Prerequisites, Agronomy 1 and Mathematics 8. Juniors and seniors; 1 lecture period and 1 4-hour laboratory period weekly. Credit, 3. Associate Professor Haskell.

8. Manures and Fertilizers. — An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Each of the important manures and fertilizers will be discussed, its origin and its chemical and physical characteristics being considered. Each material taken up will be studied in relation to its capacity to supply plant food and to its effects upon soil texture, moisture, temperature and flora. Considerable attention will be devoted to consideration of the experimental work which has been done, and which is now in progress, in manures and fertilizers. This course is intended for seniors only. Prerequisite, Agronomy 1; 3 lectures a week, with occasional seminars. Credit, 3. Dr. Brooks and Associate Professor Haskell.

ANIMAL HUSBANDRY.

Associate Professor McLean, Mr. Quaife.

Required Course.

2. Elementary Judging. — A study of the different market classes and grades of horses, cattle, sheep and swine. The purpose of this course is to familiarize beginners with the different classes of stock, and to give them a grounding in live stock judging. Text-book, Craig's "Live Stock Judging." Freshmen; 2 laboratory periods. Credit, 2.
Associate Professor McLean and Mr. Quaife.

Elective Courses.

3. Breeds and Types of Live Stock. — A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Text-book, Plumb's "Breeds and Types of Farm Animals." Prerequisite, Animal Husbandry 2. Sophomores; 1 lecture and 2 laboratory periods. Credit, 3. Mr. Quaife.

5. Principles of Breeding. — Text-book, Davenport's "Principles of Breeding." Prerequisite, Zoölogy 1. Juniors; 3 lectures. Credit, 3.
Associate Professor McLean.

6. Live-Stock Management. — The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, breaking to drive, driving, harnessing, casting, and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work. Prerequisite, Animal Husbandry 3. Juniors; 1 laboratory. Credit, 1. Mr. Quaife.

8. ADVANCED STOCK JUDGING. — This course is designed to equip Animal Husbandry students in the judging of classes of different types of live stock, to strengthen them in the selection of superior sires, and equip them for stock judging at fairs. Visits will be made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected largely from this class. Prerequisite, Animal Husbandry 3. Juniors; 2 laboratory periods. Credit, 2.
Associate Professor McLEAN.

9. FEEDING AND MANAGEMENT. — A study of the principles of animal nutrition; of the composition and qualities of feeding materials; of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production; a similar study of beef animals and beef production. Text-book, Henry's "Feeds and Feeding." Prerequisite, Animal Husbandry 3. Seniors; 3 lectures. Credit, 3.
Associate Professor McLEAN and Mr. QUAIFE.

10. FEEDING AND MANAGEMENT. — A continuation of Course 9, dealing in a similar manner with horses, sheep and swine. Prerequisite, Course 9. Seniors; 3 lectures. Credit, 3.
Associate Professor McLEAN and Mr. QUAIFE.

11. HERD AND STUD-BOOK STUDY. — An advanced course in the study of the breeds of live stock, familiarizing the student with the most productive sires and dams of the various breeds, and the successful lines and methods of breeding. Prerequisites, Animal Husbandry 5 and 8. Seniors; 2 hours. Credit, 2. Associate Professor McLEAN.

DAIRYING.

Associate Professor LOCKWOOD, Professor MARSHALL, Mr. STORY, Mr. COONS.

Elective Courses.

1. MILK AND MILK COMPOSITION. — The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for fat, test for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems. Two lecture hours and 1 2-hour laboratory period. Credit, 3.
Associate Professor LOCKWOOD.

2. BUTTERMAKING. — A study of separators and cream separation; handling milk and cream for buttermaking; preparation of starters, and ripening cream; churning; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof. Prerequisite, Course 1; one lecture hour and 2 2-hour laboratory periods. Credit, 3. Associate Professor LOCKWOOD.

3. DAIRY BACTERIOLOGY. — A study of bacteriology relative to market milk and dairy work. Prerequisites, Courses 1 and 2, Bacteriology 1; 3 2-hour laboratory periods. Credit, 3. Professor MARSHALL.

4. Market Milk and Milk Products. — A study of market milk conditions, extent and development of the business; supply and delivery; food value of milk and its use as food; milk and its relation to the public health; methods for the proper handling and preparing of milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection. The manufacture of milk products other than butter, including cheese, condensed milk, cottage cheese, casein, milk powder, ice cream, etc. Prerequisites, Dairying 1, and Bacteriology 1; two lecture hours and 1 2-hour laboratory period. Credit, 3. Associate Professor Lockwood.

5. Dairying. — A course designed primarily for teachers of secondary agriculture. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary buttermaking; proper methods of handling milk and cream; and the relation of market milk to the public health. One lecture hour and 1 2-hour laboratory period. Credit, 2. Associate Professor Lockwood.

FARM ADMINISTRATION.

Professor Foord.

Elective Courses.

3. Farm Buildings and Machinery. — A study of the material equipment of the farm aside from the land; farm buildings, their location, plan and arrangement; water supply; fencing problems; farm power; farm machinery; wagons. Prerequisites, Agronomy 1, Animal Husbandry 2, Physics 1. Primarily for seniors; 2 laboratory periods and 1 lecture hour. Credit, 3. Professor Foord.

4. Farm Management. — The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts. Prerequisites, Agronomy 1 and 3, Animal Husbandry 2 and 3. Primarily for seniors; 2 lecture or recitation hours and 1 laboratory period. Credit, 3. Professor Foord.

POULTRY HUSBANDRY.

Associate Professor Graham, Mr. Brown.

Elective Courses.

1. Elements of Poultry Culture. — This course consists of a comprehensive study of poultry-house construction, poultry-house equipment, winter-egg production, types and breeds of poultry. Juniors; 2 lectures. Credit, 2. Associate Professor Graham.

2. Elements of Poultry Culture. — This is a continuation of Course 1, treating the subjects of incubation, brooding, care of growing stock, market poultry, including capons, roasters and broilers, and diseases of poultry. Juniors; 2 lectures. Credit, 2. Associate Professor Graham.

3. Poultry Practice Work. — This is a practical laboratory course in poultry carpentry, caponizing, killing and picking; dressing and packing poultry, sorting and preparing eggs for market. Must be preceded or accompanied by Course 1. Juniors; 1 laboratory period. Credit, 1. Mr. Brown.

4. Incubation and Brooding. — In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg, and the care of sitting hens. This course must be preceded or accompanied by Course 2. Juniors; time to be arranged. Credit, 1 to 3. Mr. Brown.

5. Pen Management. — This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls, and profit and loss; must be preceded or accompanied by Course 1. Juniors; time to be arranged. Credit, 1. Mr. Brown.

6. Poultry Management. — In this course a detailed study of large poultry farms and equipment, such as bone cutters, feed cutters, cramming machines, etc., will be carried on. It includes the laying out and planning of poultry buildings of all kinds, the mating of fowls, and the preparing of birds for exhibition. Attention to poultry diseases and investigation work carried on by experiment stations is prominent in this course. A few good poultry plants will be visited by the class for practical demonstrations. Prerequisites, Courses 1, 2, 3 and 4. Seniors; 2 lectures, 1 laboratory period. Credit, 3. Associate Professor Graham and Mr. Brown.

7. Advanced Poultry Judging. — This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The American Standard of Perfection will be used as a text. Prerequisites, Courses 1, 2, 3, 4 and 5. Seniors; 1 lecture and 2 laboratory periods. Credit, 3. Associate Professor Graham and Mr. Brown.

9. Market Poultry and Poultry Products. — This course includes the study of market classifications of poultry, eggs and feathers; the requirements of different markets, methods of marketing, advantages and disadvantages of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Judging and scoring of market poultry, both alive and dressed, and market eggs will be an important feature of this course. Prerequisites, Courses 1, 2 and 3. Seniors; 1 lecture or conference period and laboratory periods to be arranged. Credit, 3.

Associate Professor Graham and Mr. Brown.

DIVISION OF HORTICULTURE.

Professor WAUGH.

[The general subject of horticulture divides naturally into the subjects of pomology, floriculture, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.]

Required Course (General).

2. NURSERY PRACTICE. — This course treats of the fundamental operations of horticulture — propagation, pruning, cultivation — as related to the physiology of the plant. Lectures and practicums; Bailey's "Nursery Book" as text in propagation. Sophomores; 2 hours. Credit, 2.

Mr. CHENOWETH.

Elective Courses (General).

3. PLANT MATERIALS. — This course aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them. Prerequisite, Horticulture 2; 2 lecture periods and 1 laboratory period. Credit, 3.

Professor WHITE.

4. PLANT MATERIALS. — A continuation of Course 3, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions. Prerequisite, Horticulture 3; 2 lecture periods and 1 laboratory period. Credit, 3. Professor WHITE.

6. PLANT BREEDING. — This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops. Seniors and graduates; open only to students well prepared in agricultural or horticultural subjects; 2 lecture periods and 1 2-hour laboratory period. [Not given in 1913–14.] Credit, 3.

FLORICULTURE.

Professor WHITE.

Elective Courses.

1. GREENHOUSE MANAGEMENT. — This course is designed to familiarize students with methods followed in the management of greenhouse crops. The students are instructed in the practical operation of glazing concrete, bench construction, bulb culture, greenhouse watering, fumigating and ventilating, in the care of furnaces, and in the methods of propagation of green-

house plants by seeds and cuttings. This is designed as a laboratory course, and students electing it will be expected to arrange their hours according to the needs of the work. Prerequisite, Horticulture 2. Juniors; 7 hours a week. Credit, 4. Professor WHITE.

2. GREENHOUSE MANAGEMENT. — A continuation of Course 1, including also a study of the location, arrangement and construction of greenhouses; the drawing of plans for commercial and private ranges, to show foundations and details in construction of superstructure; arrangement of heating pipes; estimate of comparative cost of different methods of construction; drafting specifications. Design making and table decorations are considered in this course. Juniors; prerequisite, Floriculture 1; 7 hours as stated under Course 1. Credit, 4. Professor WHITE.

3. FALL GREENHOUSE CROPS. — A study of important fall and winter crops and their care, — chrysanthemums, carnations, violets, roses, palms and various conservatory plants; the importation, purchase and growth of bulbous material; the preparation of material for forcing; house and church decorating. Lectures, text-books and laboratory exercises. Prerequisites, Floriculture 1 and 2. Seniors; 5 hours. Credit, 3. Professor WHITE.

4. SPRING GREENHOUSE CROPS. — The culture of individual crops in their relation to spring work in a florist establishment. A critical study of methods of propagating bedding plants, the nature and use of these plants, practice in planting them and in the spring care of herbaceous perennials and wholesale and retail marketing of spring plants. Lectures, text-books and practical exercises. Seniors; prerequisites, Floriculture 1, 2 and 3; 5 hours. Credit, 3. Professor WHITE.

FORESTRY.

Professor CLARK.

Elective Courses.

1. PRINCIPLES OF FORESTRY. — A lecture course for the purpose of giving the students a general view of the whole field of forestry and what forestry attempts to accomplish and has accomplished. Two lectures; juniors and seniors; not required of students who propose to major in forestry. Credit, 2. Professor CLARK.

3. DENDROLOGY. — During the first part of the semester frequent field trips will be made to identify and study the habits of our native forest trees. Later, the classification, range, distribution, forest habits, quality, uses and identification of wood of the commercial timber trees of the United States will be studied. Two 2-hour periods; lectures, recitations, laboratory or field work at option of instructor; juniors. Credit, 3. Professor CLARK.

4. SILVICULTURE. — Factors influencing forest growth; forest types; silvicultural systems; care and protection of forests; forest description; forest nursery practice and forest planting. Three lectures weekly until May 1; during May and June, one lecture and one 4-hour field period weekly; juniors. Prerequisite, Forestry 3. Credit, 3. Professor CLARK.

5. Forest Mensuration. — Methods of determining the volume of trees, logs and entire forests. Methods of computing volume tables, tree and forest growth and yield tables. Timber estimating. Three lectures; 72 hours of field work; seniors. Credit, 5. Professor Clark.

6. Forest Valuation and Regulation. — Methods of determining the costs of growing timber crops and of arriving at the value of future growth or standing immature growth. Methods of regulating the harvest of crops so as to secure a sustained or annual yield. Prerequisite, Forestry 5; seniors; 3 lectures. Credit, 3 Professor Clark.

LANDSCAPE GARDENING.

Professor Waugh, Mr. Harrison.

Elective Courses.

1. Elements of Landscape Gardening. — Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Students should have preparation in surveying, mathematics, plant materials and drawing. Must be followed by Course 2. Juniors; 6 hours a week. Credit, 3. Mr. Harrison.

2. Elements of Landscape Gardening. — As stated under Course 1. Prerequisite, Course 1.

3. General Design. — Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens and parks and private grounds; written reports of individual problems. Seniors; prerequisites, Landscape Gardening 1 and 2, and either plant materials (Horticulture 3 and 4) or advanced mathematics; must be followed by Course 4; 6 hours. Credit, 3. Professor Waugh.

4. General Design. — As stated under Course 3. Prerequisite, Course 3.

5. Theory of Landscape Art. — The general theory and applications of landscape study, including a brief history of the art. Seniors and graduates; 2 hours. Credit, 2. Professor Waugh.

6. Architecture. — The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing; 2 hours. Credit, 2. (Alternating with Course 10.) Mr. Harrison.

7. Civic Art. — The principles and applications of modern civic art, including city design, city improvement, village improvement and rural improvement. Prerequisites, Courses 1, 2 and 3; must be followed by Course 8; 6 hours. Credit, 3. Professor Waugh.

8. Civic Art. — As stated under Course 7. Prerequisite, Course 7.

10. Construction and Maintenance. — Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc. Two hours. Credit, 2. (Alternating with Course 6 and not to be given in 1912–13.) Mr. Harrison.

MARKET GARDENING.

Assistant Professor Yeaw.

Elective Courses.

2. Elements of Market Gardening. — A course designed for an introduction to market gardening as a business. The work consists primarily of actual field experience in handling vegetable crops from seed to maturity. This is supplemented with lectures and text-book, in which a study of methods, soils, fertilization, tillage and management is made. Juniors; 5 hours. Credit, 3. Assistant Professor Yeaw.

3. Advanced Market Gardening. — A continuation of the work begun in Market Gardening 2, taking up problems of seed growing, selection of varieties, crop management, harvesting, storage and marketing. A study is made of the greenhouse vegetable industry, and considerable time devoted to growing the special forced crops. Some time is given to a systematic study of vegetable description, classification and nomenclature. Collateral reading is required. Seniors; prerequisite, Market Gardening 2; 5 hours. Credit, 3. Assistant Professor Yeaw.

POMOLOGY.

Professor Sears, Mr. Chenoweth, Mr. Rees.

Elective Courses.

1. Practical Pomology. — *General.* — A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of stock, pruning, spraying, etc. Text and reference books; field and laboratory exercises. Prerequisite, Horticulture 2. Juniors; 4 hours. Credit, 3. Professor Sears.

2. Practical Pomology. — *Special.* — The special application of the general principles discussed in Course 1 to the culture of the principal kinds of fruits, such as apples, pears, peaches, plums, cherries and quinces; grape culture and the culture of small fruits, such as blackberries, raspberries, currants, gooseberries and strawberries. Text-books, lectures and reference books; field and laboratory exercises. Prerequisites, Horticulture 2 and Pomology 1. Juniors; 4 hours. Credit, 3. Professor Sears.

3. Systematic Pomology. — A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Text-books, laboratory and field exercises. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 4 hours. Credit, 3. Mr. Chenoweth.

4. Commercial Pomology. — The storing and marketing of fruits; includes a discussion of storage houses, the handling and storing of fruits, fruit packages, methods of grading and packing, etc. Text and reference books; laboratory exercises. Seniors; prerequisites, Horticulture 2, Pomology 1, 2 and 3; 4 hours. Credit, 3. Mr. Chenoweth.

6. Spraying. — A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small fruit plantations. Prerequisites, Horticulture 2, Pomology 1 and 2. Seniors; 3 hours (1 lecture period and 1 laboratory period). Credit, 2.

Professor Sears.

DRAWING.

Mr. Harrison.

Elective Courses.

1. Freehand Drawing. — Lettering; freehand perspective; sketching from type models, leaves, flowers and trees, insects and small animals; laying flat and graded washes in water colors; water color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink. Juniors; 6 hours. Credit, 3. Mr. Harrison.

2. Mechanical Drawing. — Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry. Juniors; 6 hours. Credit 3.

Mr. Harrison.

DIVISION OF SCIENCE.

Professor PAIGE.

BOTANY.

Professor STONE, Assistant Professor OSMUN, Mr. McLAUGHLIN, Mr. SMITH.

[The object of the courses in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. Undergraduate work extending through five semesters is offered. Considerable latitude is allowed students in the senior year in their electives; and, besides the courses here outlined, students often take up the study of histology or of systematic botany, the microscopic examination of pure and adulterated human and cattle foods, spices and drugs, etc. Students sufficiently prepared are occasionally permitted to undertake special physiological and pathological investigations. A botanical conference is held monthly wherein new problems in botanical science are considered by graduate students and the seniors who elect botany.]

Required Course.

2. GENERAL BOTANY. — The morphology, physiology and classification of plants. This course is fundamental. Its aim is to lay a foundation for the more specialized courses in botany which follow and to provide a general knowledge of the science for those students who will not take further work in the department. This course is prerequisite to all other courses given by the department. Laboratory work consists in the microscopic study of representatives of all the more important plant groups. This phase of the work is almost entirely devoted to morphology and histology, especial attention being given to the structure of higher plants. The lectures aim to amplify and interpret the laboratory work, dealing also with the function (physiology), classification (taxonomy) and ecology of plants. Each student is required to collect and prepare an herbarium of 75 species of native plants. Gray's "New Manual of Botany" is used in determining and naming plants. Though only 1 lecture period is scheduled for this course, it is understood that laboratory hours may be used for lectures at the discretion of the instructor. Sophomores; 1 lecture; 3 laboratory periods. Credit, 4.

Assistant Professor OSMUN and Mr. McLAUGHLIN.

Elective Courses.

3. CRYPTOGAMIC BOTANY. — Systematic study of typical forms of the lower plants (bacteria, algæ, fungi, lichens, mosses and ferns); instruction in laboratory technique and methods, and the making of herbaria of lichens, mosses and ferns. Laboratory work and lectures; field excursions for the purpose of observing environmental habits and collecting material for laboratory study; collateral reading. This course is intended for those students who wish to specialize in biology; its purpose is to afford more thorough scientific training than is offered in Course 5, and students electing this course may attend the lectures in Course 5. Prerequisite, Botany 2. Primarily for juniors. 1 lecture hour and 3 2-hour laboratory periods. Credit, 4.

Assistant Professor OSMUN.

4. CRYPTOGAMIC BOTANY. — This is a continuation of Course 3. Prerequisites, Botany 2 and 3. Primarily for juniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 2. Assistant Professor OSMUN.

5. PLANT PATHOLOGY. — This course comprises a study of the common diseases of crops and consideration of the methods for their prevention and control, and is intended especially for students in horticulture and agriculture. Laboratory work and lectures. Prerequisite, Botany 2. Primarily for juniors; 1 1-hour lecture and 1 2-hour laboratory period. Credit, 2.
Professor STONE, Assistant Professor OSMUN and Mr. McLAUGHLIN.

7. PLANT PATHOLOGY. — This course includes a study of the diseases of one or more crops and the methods of controlling them. Laboratory work and lectures, together with extensive reading of experiment station literature. The course is intended for those who wish to become more familiar with the diseases of one or more groups of economic plants. Prerequisite, Botany 2. Seniors; students who take this course and continue in botany must take Course 8; 1 lecture period and 3 3-hour laboratory periods. Credit, 5. Professor STONE.

8. PLANT PATHOLOGY. — As stated in Course 7. Prerequisite, Course 7.

9. ECONOMIC FUNGI. — This course comprises the study of economic fungi from a technical point of view, and is intended for those students who wish for a more comprehensive knowledge of the phylogenetic relationship of fungi. Laboratory work and lectures. Problems of a practical or technical nature intimately associated with the control of diseases are taken up. Special monographs and more important station literature treating of the life history of fungi, etc., are studied. Prerequisites, Botany 2, 3 and 4. Must be followed by Course 10; seniors; 1 1-hour lecture period and 2 or 3 3-hour laboratory periods. Credit, 4 or 5.
Professor STONE.

10. ECONOMIC FUNGI. — As stated in Course 9. Prerequisite, Course 9.

11. PLANT PHYSIOLOGY. — This course is largely experimental and is especially adapted to the needs of students who are taking chemistry. Laboratory work and lectures; various handbooks on plant physiology. Prerequisite, Botany 2. Must be followed by Course 12; seniors; 1 1-hour lecture period and 3 3-hour laboratory periods. Credit, 5.
Professor STONE and Mr. McLAUGHLIN.

12. PLANT PHYSIOLOGY. — As stated in Course 11. Prerequisite, Course 11.

13. SHADE-TREE MANAGEMENT. — Physiology and pathology of shade trees. This course includes a comprehensive study of the diseases, structure and functions of trees and shrubs, and of every agency which in any way affects shade trees. Laboratory work and lectures; extensive reference reading. Designed for those students who intend to take charge of parks

or large estates, or to become tree wardens, city foresters, landscape gardeners or professional advisers and caretakers. Prerequisite, Botany 2. Must be followed by Course 14; seniors; 1 1-hour lecture period and 2 3-hour laboratory periods. Credit, 4. Professor Stone.

14. Shade-Tree Management. — Physiology and pathology of shade trees. As stated in Course 13. Prerequisite, Course 13.

GENERAL AND AGRICULTURAL CHEMISTRY.

Professors Lindsey and Wellington,[1] Associate Professors Chamberlain and Peters, Assistant Professor Anderson, Messrs. Bogue, Noyes, Fowler and Gates.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the other sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and who intend following chemistry as a vocation are prepared for positions as instructors in high schools and colleges, in the agricultural experiment stations, the United States Department of Agriculture, as well as in fertilizer, cattle food, sugar and dairy industries. Students are encouraged to take graduate work leading especially to the degree of M.Sc., and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.]

Required Courses.

1. General Chemistry. — *The Non-metals.* — An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements and their compounds. Kahlenberg's "Outlines of Chemistry" is used as a text. The laboratory work is of two kinds. Those beginning the subject form one division and those who present chemistry for entrance are grouped in other divisions. The advance divisions, in addition to work not usually done in high schools, study simple volumetric quantitative processes such as the determination of the hardness of water, the available oxygen in hydrogen peroxide, the chlorine in soluble chlorides, the oxygen in bleaching powder and the strengths of solutions of acids and bases. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.
Associate Professor Peters, Assistant Professor Anderson,
Mr. Bogue and Graduate Assistants.

2. General Chemistry. — *The Metals.* — A continuation of Course 1. A study of the metals and their compounds. The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate from gas liquor, sulfur and arsenic insecticides and superphosphates, in addition to preparations outlined in Blanchard's "Synthetic Inorganic Chemistry." Attention is paid to the subjects of mass action and colloids. Prerequisite, Course 1. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.
Associate Professor Peters, Assistant Professor Anderson,
Mr. Bogue and Graduate Assistants.

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[1] Absent on leave, second semester; courses in charge of Associate Professor Peters.

Elective Courses.

3. Qualitative Analysis. — *Basic.* — A course in the systematic analysis of metallic salts, presented from the ionic viewpoint. The student studies closely the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Gooch and Browning's "Outlines of Qualitative Analysis," with Böttger's "Qualitative Analysis" and Treadwell-Hall's "Qualitative Analysis" for reference. Prerequisite, Course 2; should be taken, particularly, by all intending to follow chemistry as a vocation. Sophomores; lecture, 1 hour; laboratory, 2 hours. Credit, 3. Assistant Professor Anderson and Mr. Noyes.

4. Qualitative Analysis. — *Acidic.* — A continuation of Course 3. A large part of the semester is spent in the examination qualitatively of minerals and of agricultural products. Prerequisite, Course 3. Sophomores; lecture, 1 hour; laboratory, 2 hours. Credit, 3.
Assistant Professor Anderson and Mr. Noyes.

5. Organic Chemistry. — This course, with Course 6, continues through the junior year. The two courses are designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates, proteins, etc. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and thus for future work in agricultural chemical investigation. Prerequisites, Courses 1, 2, 3 and 4 (courses 3 and 4 will not be required as prerequisites for those majoring in other courses than chemistry). Juniors; those electing Course 5 are expected to elect Course 6. Lectures, 3 hours; laboratory, 4 hours. Credit, 5.
Associate Professor Chamberlain and Mr. Fowler.

6. As stated under Course 5.

7. Agricultural Chemistry. — This course and Course 8 are designed as alternatives for Courses 5 and 6. They are especially intended for those who, having completed Courses 1 and 2, do not care to continue the study of chemistry for itself, but are planning to enter practical agricultural work and desire a further knowledge of chemistry as it is related directly to practical agriculture and agricultural problems. The work is planned in two parts, viz.: *Course 7, Inorganic Agricultural Chemistry*, the study of the general composition, properties and reactions of soils and fertilizers, and in addition to this the study of some of the

more important fungicides and insecticides, and the common materials of construction, such as tile, brick, cements, paints, oils, etc.; and *Course 8, Organic Agricultural Chemistry,* the study of the composition, physiological processes, uses and nutritive value of plants, and the composition and general processes of nutrition and growth of animals; also the study of products related to plants and animals, such as milk, butter, sugar, maple syrup, denatured alcohol, wood pulp, paper, etc. The treatment of the subject in both of these courses is entirely general, avoiding all complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the chemical aspects of agricultural processes and products. Prerequisites, Courses 1 and 2. Juniors; those electing Course 7 are expected to elect Course 8. Lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor CHAMBERLAIN and Mr. FOWLER.

8. ORGANIC AGRICULTURAL CHEMISTRY. — As stated under Course 7.

9. QUANTITATIVE ANALYSIS. — Instruction in this course includes the gravimetric and volumetric determinations of some of the commoner metals and non-metals in minerals and industrial products. Aside from teaching accurate observation and care in manipulation, it is intended for those who would learn the exact methods for determining the elements, particularly, in inorganic substances, and is the forerunner of other courses intended to fit men to become expert analysts. Talbot's "Quantitative Chemical Analysis" is used as a text. Prerequisites, Courses 1, 2, 3 and 4. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor WELLINGTON and Associate Professor PETERS.

10. AGRICULTURAL CHEMICAL ANALYSIS. — In this course and Course 11 the methods previously studied, and other approved methods, are applied to the examination of agricultural materials. The analysis of fertilizers, insecticides, fungicides and soils is followed by that of cattle foods, dairy products, sugars, starches and allied substances. Prerequisite, Course 9. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor WELLINGTON, Associate Professor PETERS.

11. AGRICULTURAL CHEMICAL ANALYSIS. — As stated under Course 10. Prerequisite, Course 10. Seniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor WELLINGTON and Assistant.

13. PHYSIOLOGICAL CHEMISTRY. — This course is intended to be supplementary to Courses 5 and 6 and Courses 7 and 8. To those who expect to take up scientific work in botany, agronomy, animal husbandry and bacteriology, and who have had Courses 5 and 6, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 5 and 6 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory,

experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion. The course gives additional training in the chemical problems of agricultural experiment station work, especially those connected with investigations in animal and plant nutrition. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give an opportunity for a more detailed study of the chemistry and physiology of problems which were treated generally in Courses 7 and 8. Prerequisites, preferably, Courses 5 and 6 or 7 and 8. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.
Associate Professor CHAMBERLAIN and Mr. FOWLER.

[GENERAL STATEMENT CONCERNING COURSES 12, 14 AND 16. — Each student electing either of these courses will be required to take up and follow out some special line of work, the object being to acquaint him with methods of original inquiry. A single concrete example may be found in a comparative study of the different methods for the determination of the several forms of nitrogen. A thesis may not be required, but frequent consultation of the literature bearing on the subject will be necessary. These courses are valuable for all chemists, and particularly so for those intending to take up experiment station work. A student may choose any one but not two of these separate courses.]

12. SPECIAL WORK IN AGRICULTURAL CHEMICAL ANALYSIS. — Topics for laboratory study will be assigned to each student. Prerequisite, Course 11. Seniors; laboratory, 10 hours. Credit, 5.
Professor WELLINGTON and Assistant.

14. SPECIAL WORK IN PHYSIOLOGICAL AND ORGANIC AGRICULTURAL CHEMISTRY. — In this course, as in Courses 12 and 16, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, etc. Prerequisites, Courses 5, 6 and 13. Seniors; laboratory, 10 hours. Credit, 5.
Associate Professor CHAMBERLAIN and Mr. FOWLER.

16. SPECIAL WORK IN PHYSICAL CHEMISTRY. — The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student will select one line of work and follow it through the course, repeating some of the original work. Prerequisite, Course 15. Laboratory, 10 hours. Credit, 5. Assistant Professor ANDERSON.

15. PHYSICAL CHEMISTRY. — A résumé of general chemistry from the viewpoint of physical chemistry and the application of physical chemistry to agricultural chemistry. Prerequisite, Course 9. Juniors and seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.
Assistant Professor ANDERSON.

18. History of Chemistry. — An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at more length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course. [Not given in 1912–13.] Seniors; lectures, 2 hours. Credit, 2. Professor Wellington.

ENTOMOLOGY.

Professor Fernald, Associate Professor Crampton, Assistant Professor Gates, Mr. Martin, Mr. Davis.

Elective Courses.

1. General and Economic Entomology. — Course 1 comprises a general introduction to the study of insects, including studies on their structure as applied to their identification; the principles of classification; a systematic examination of the different groups and of the most important economic insects of each group, including their life histories and habits, recognition of their work as shown in the collections, and methods for their control. The most important insecticides and their preparation and application are also treated. Students electing Course 1 are expected to take Course 2. Juniors; 3 lecture periods. Credit, 3. Professor Fernald.

2. General and Economic Entomology. — A continuation of Course 1, with laboratory and field work on methods of collecting, preserving and studying insects and their work. Juniors; 2 laboratory or field periods. Credit, 3. Professor Fernald.

3. Advanced Entomology. — This course is subdivided, the time spent on the various subdivisions differing somewhat according to the particular needs of those taking it; and it is to a large degree given in the form of individual instruction, special attention being paid to the pests attacking the particular crops in which the student is most interested. The student may specialize in fruit pests, market-garden pests, greenhouse pests, field crop pests, etc., to a large extent, in accordance with his plans for future work.

A. Morphology. — Careful studies of the structure of insects belonging to each of the larger and more important orders, together with lectures on the subject, followed by the identification of insects of each of these groups and the study of the collections, to teach the use of the analytical tables and of structural characters in the determination of insects.

B. Histology. — Lectures on the internal anatomy and histology of the various organs, with particular reference to those affected by the various insecticides.

C. Insecticides and Apparatus. — Lectures on the chemistry, preparation and application of the different insecticides, their merits and defects; tests for detecting adulterations; comparative tests of nozzles and other apparatus; and a study of other methods of insect control, together with laboratory work.

D. Coccidology. — Laboratory work on methods of preserving, mounting and identifying scale insects, particular attention being given to those of greatest economic importance.

E. Bibliography. — Studies of the various entomological publications and of the methods of finding the literature on any insect.

F. Special Studies. — In these studies the insects most closely related to the future occupation of the student will receive attention. The results of these studies are brought together in the form of an essay or thesis; this will include all the essentials of what is known of the life history, habits and injuries caused by each insect studied, together with methods of treatment, and a list of the best articles found in the course of the work. Comstock's "Manual for the Study of Insects" is used in the laboratory work. Seniors; prerequisite, Entomology 2; students electing Course 3 are expected to take Course 4; 1 1-hour lecture period and 3 2-hour laboratory or field periods. Credit, 4.

Professor FERNALD, Associate Professor CRAMPTON, Mr. MARTIN.

4. ADVANCED ENTOMOLOGY. — As stated in Course 3. Prerequisite, Course 3.

5. FOREST INSECTS. — A study of insects injurious to forest trees and of methods for their control, with laboratory and field work on these insects, and a study of what has been published about them. Seniors; prerequisites, Entomology 1 and 2; 1 lecture and 2 2-hour laboratory or field exercises. Credit, 3. Professor FERNALD.

8. BEEKEEPING. — This course comprises a general consideration of the biology of the honey bee and of practical beekeeping. Some topics covered are: phylogeny, life history, general behavior and instincts, structure, products, relations of bees to plants and the honey flora. The course aims particularly to afford first-hand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational or apicultural. Bee diseases, a thorough understanding of which is fundamental to the industry, are considered. So far as possible the work is made individual in constructing materials and apparatus. Juniors; seniors may elect. Courses 1 and 2 form a desirable preparation; 2 lectures; 1 2-hour laboratory period. Credit, 3.

Assistant Professor GATES, Mr. DAVIS.

[10.[1] ADVANCED BEEKEEPING. — This course deals with the advanced and special problems of the beekeeper. Besides considering those difficulties which at present confront the industry, subjects necessarily of limited treatment in the previous course are expanded for the development of particular technique and manipulation. Apiary management and the principles of queen rearing are practiced in accord with the season. The course should further qualify for apicultural instruction, inspection service, and afford familiarity with the special literature and method needed in investigation and research. The policy of individual instruction will be contained in so far as practicable. Primarily for seniors, but juniors may elect; prerequisite, Course 8; 1 lecture, 1 laboratory period. Credit, 2. Assistant Professor Gates.]

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[1] The announcement of this course is made provisionally.

MATHEMATICS AND CIVIL ENGINEERING.

Professor Ostrander, Mr. Duncan, Mr. Machmer, Mr. Parsons.

Required Courses.

1. Higher Algebra. — A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra." Freshmen; 3 hours a week. Credit, 3. Mr. Machmer and Mr. Parsons.

2. Higher Algebra. — As stated under Course 1. Mr. Machmer.

3. Solid Geometry. — Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Freshmen; required unless accepted for admission; 2 hours a week. Credit, 2. Mr. Duncan.

4. Plane Trigonometry (in Charge of Department of Physics). — The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry." Required unless accepted for admission. Freshmen; 3 hours. Credit, 3. Professor Hasbrouck and Captain Martin.

Elective Courses.

6. Plane Surveying. — The elements of the subject, including the adjustment and use of the usual instruments. Text-book and lectures. Sophomores; 6 hours a week. Credit, 3. Mr. Duncan and Mr. Parsons.

7. Analytic Geometry. — A discussion of the geometry of the line, the circle, of conic sections and of the higher plane curves. Fine and Thompson's "Coördinate Geometry." Prerequisites, Mathematics 1, 2, 3 and 4. Primarily for juniors; 3 hours a week. Credit, 3. Professor Ostrander.

8. Differential and Integral Calculus. — A first course in the subject, with some of the more important applications. Nichol's "Differential and Integral Calculus." Prerequisites, Mathematics 1, 2, 3, 4 and 7. Primarily for juniors; 5 hours. Credit, 5. Professor Ostrander.

10. Advanced Surveying. — Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. [Not given in 1912–13.] Text-book and lectures; 6 hours. Credit, 5.
Professor Ostrander.

11. Hydraulics and Sanitary Engineering. — Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. [Not given in 1912–13.] Text-book and lectures; 3 hours. Credit, 3. Professor Ostrander.

12. Elementary Structures. — An elementary course in roofs and bridges. Text-book and lectures; 6 hours. [Not given in 1913–14.] Credit, 5. Professor Ostrander.

13. Materials of Construction, Foundations and Masonry Construction. — Text-book and lectures; 4 hours. [Not given in 1913–14.] Credit, 3. Professor Ostrander.

15. Applied Mechanics. — A course in applied mechanics, based on the calculus, with problems. Text-books and lectures. Prerequisites, Mathematics 7, 10; 3 hours. Credit, 3. Professor Ostrander.

MICROBIOLOGY.

Professor Marshall.

[The program of courses in the recently established department of microbiology has not been completed. Work will be outlined in pathology, bacteriology, etc., but only the course in dairy bacteriology (Dairying 3) has yet been offered.]

3. Dairy Bacteriology. — A study of bacteriology relative to market milk and dairy work. Prerequisites, Courses 1 and 2, and Bacteriology 1 (see Veterinary science); 3 2-hour laboratory periods. Credit, 3.
Professor Marshall.

PHYSICS.

Professor Hasbrouck, Captain Martin, Mr. Butman.

[The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.]

Required Course.

1. General Physics. — General physics covers mechanics of solids, mechanics of fluids, wave motion and heat. These topics are chosen for the required work because they are regarded as the most fundamental of all, and there is no part of the work in physics more necessary for the student who plans to take up practical farming. Course given by text-book and lectures. Sophomores; 4 hours' class-room work and 1 laboratory period. Credit, 5. Professor Hasbrouck and Mr. Butman.

Elective Courses.

2. GENERAL PHYSICS. — Electricity and light. Text-book, lectures, recitations and laboratory work. Sophomores; 2 hours of class-room work and 1 laboratory period. Credit, 3. Mr. BUTMAN.

3. OPTICAL INSTRUMENTS AND LIGHT. — Three-hour lecture course open to juniors and seniors; 3 hours. Credit, 3. Mr. BUTMAN.

4. ELECTRICITY AND HEAT. — Three-hour lecture and laboratory course open to juniors and seniors; 3 hours. Credit, 3. Mr. BUTMAN.

[Mathematics 4 (trigonometry) is, for convenience of grouping, listed under Mathematics, although in charge of the Department of Physics.]

VETERINARY SCIENCE.

Professor PAIGE, Assistant Professor GAGE.

[The courses in veterinary science have been arranged to meet the needs of students who purpose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.[1]

1. INTRODUCTORY BACTERIOLOGY. — The object of this course is to acquaint the student with the various organisms found in air, water, soil, milk and the body, and with the relation of these organisms to such processes as decomposition, fermentation and digestion, and to the production of disease. Toxic substances resulting from the growth of organisms, and the antitoxins used to counteract their action, are considered. Lectures, recitations and laboratory work. Seniors; 3 2-hour laboratory exercises. Credit, 3.
Professor PAIGE and Assistant Professor GAGE.

2. BACTERIOLOGY. — A continuation of Course 1, taking up more advanced problems.

3. VETERINARY SCIENCE. — A course treating of veterinary hygiene, comparative anatomy and general pathology; veterinary materia medica and therapeutics; the theory and practice of veterinary medicine; general, special and operative surgery; and veterinary bacteriology and parasitology. Lectures, clinics, demonstrations and laboratory exercises. Must be followed by Course 4. Seniors; 5 hours. Credit, 5. Professor PAIGE.

4. VETERINARY SCIENCE. — As stated under Course 3.

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[1] Revision of the plan of courses, to be in effect in 1913–14, is announced.

ZOÖLOGY AND GEOLOGY.

Associate Professor GORDON, Mr. PARKER.

ZOÖLOGY.

Required Course.

1. ANIMAL MORPHOLOGY. — This course presents the underlying principles of biology and the zoölogical part of an introductory course. Laboratory dissection and lectures. Sophomores; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Associate Professor GORDON.

Elective Courses.

3. COMPARATIVE INVERTEBRATE OR VERTEBRATE ZOÖLOGY. — These are parallel courses running throughout the year and are scheduled for the same hour. The student may elect one or the other, but not both in the same year. Comparative invertebrate zoölogy is intended primarily for future students in entomology, but is open to any one. Vertebrate zoölogy presents the comparative morphology of vertebrate forms. Parker & Haswell's "Text-book of Zoölogy," Vol. I., is required for invertebrate zoölogy, and Vol. II. for vertebrate zoölogy. Primarily for juniors; prerequisite for these courses, Course 1, or its equivalent; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Associate Professor GORDON.

4. COMPARATIVE INVERTEBRATE OR VERTEBRATE ZOÖLOGY. — Continuation of Course 3. One lecture hour and 2 2-hour laboratory periods. Credit, 3. Associate Professor GORDON.

5. ADVANCED ZOÖLOGY.[1] — A course in animal parasites is offered to seniors. This course is a survey of this special field, with laboratory dissection, lecture work and outside reading. Not open to fewer than three students. Prerequisites, Course 1 and Course 3 in comparative invertebrate zoölogy; 2 1-hour periods, or their equivalent and 3 2-hour periods. Credit, 5. Associate Professor GORDON.

6. ADVANCED ZOÖLOGY.[1] — Course 5, continued. One 1-hour period and 2 2-hour periods. Credit, 3. Associate Professor GORDON.

GRADUATE COURSES. — See "Graduate School."

GEOLOGY.

Elective Course.

2. ELEMENTARY GEOLOGY. — Rock-forming minerals; rock types; rock weathering; dynamical, structural and surface geology. Lectures, map and field work. Sophomores; 1 1-hour period and 2 2-hour periods. Credit, 3. Associate Professor GORDON.

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[1] Courses 5 and 6 are also available as a minor for the degrees of master of science or doctor of philosophy.

DIVISION OF THE HUMANITIES.

Professor SPRAGUE.

ECONOMICS AND SOCIOLOGY.

Professor SPRAGUE.

Required Course.

1. POLITICAL ECONOMY. — An introductory course. A study of the nature and scope of economics; the evolution and organization of the present economic system, the principles of production, exchange and consumption. This course will take up such topics as value, rentals, population, labor and its problems, capital, interest and profits, systems and factors of production, tariffs and commerce. Students will be called upon to analyze industrial plants in actual operation. Text-books, lectures and general discussions; a required course, but it may be taken in either junior or senior year; 3 hours. Credit, 3. Professor SPRAGUE.

Elective Courses.

2. INDUSTRIAL PROBLEMS. — A course in the most important industrial problems of the day, covering the methods of organizations of labor and capital, systems of industrial remuneration, means of securing industrial peace, legal status of labor unions and their activities, protective legislation for workmen and employers, the problems of immigration, the sweated industries, prison labor, child labor and industrial education. Text-book, with collateral readings, lectures and discussions; 3 hours. Credit, 3. Professor SPRAGUE.

3. SOCIAL INSTITUTIONS AND SOCIAL PROBLEMS. — This course is devoted to the study of the social institutions, such as the family, the church, State and property; and to such current social problems as divorces, race suicide, crime and prison reform, poverty and its relief, social effects of low wages, child labor, overwork, immigration and congestion of population. The later weeks of the semester will be given to a short introduction to sociological theory. The correctional and charitable institutions of Massachusetts will be studied in considerable detail. Readings, lectures, papers; 3 hours. Credit, 3. Professor SPRAGUE.

4. MODERN SOCIAL REFORM MOVEMENTS. — The history of property and its vital issues in modern times. The socialistic systems, anarchy and communism. Systems of workingmen's insurance in Europe and America, and other methods of relief from the chances of life. Educational reforms, in process, to meet the demands of a new age, and legislative remedies for the evils of social change and maladjustment. The crisis of Christianity under modern capitalized industrialism. These topics indicate the nature of the subjects studied. This course follows Economics 3. Three hours. Credit, 3. Professor SPRAGUE.

5. Public Finance, Money and Banking. — This course follows Economics 1. It will take up taxation and the various systems for collecting public revenue in Europe and America, with the problems involved; the history of money and the systems of banking and finance now in operation; the causes and problems of economic crises and depressions; the currency problems of the United States. Readings, lectures and discussions; 3 hours. Credit, 3. Professor Sprague.

6. Economic History. — This course will be divided between the economic history of Europe and that of America. An outline history will be followed with special study of selected epochal periods and important topics. Three hours. Credit, 3. Professor Sprague.

8. Anthropology; the History of Human Civilization. — The evolutionary origin and history of man; characteristics of primitive men, departure from the animal status, and the beginnings of civilization; development of industries, arts and sciences; the growth of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern conditions, will constitute the subject matter of the course. Three hours. Credit, 3. Professor Sprague.

HISTORY AND GOVERNMENT.

Associate Professor Eyerly, Mr. Holcomb.

Elective Courses.

1. Elements of Political Science. — Nature and scope of political science; origin and evolution of the State; systems of government in the principal European States; organization and working of the national and of the State governments of the United States; relation of government to political parties and to public opinion; the functions of government as related to labor and commerce. Three hours. Credit, 3.
Associate Professor Eyerly.

2. Local Political Institutions. — A comparative study of the organization, functions and achievements of country and city groups, especially as these are concerned with such matters as taxation, finance, licenses, franchises, public ownership, highways, transportation and communication, water supply, fire protection, public lighting, markets, food inspection, garbage and sewage disposal, infectious diseases, housing conditions, police force, parks and playgrounds, libraries, schools, care of dependents. Three hours. Credit, 3. Associate Professor Eyerly.

3. The History of New England. — In this course, New England is regarded as a unit. Although the history of agriculture and rural life is treated with special fulness, ample attention is given to political, religious and ethical history. It is hoped that the student will not only be led to an intelligent understanding of present economic conditions, but will also be imbued with a progressive loyalty to the highest ideals of the New England of the past. Lectures and required reading; 3 hours. Credit, 3. Mr. Holcomb.

5. The History of Ideals. — This course treats history from the idealistic rather than from the economic, point of view. It attempts to define the great ideals which have impelled some of the most important social, political, esthetic, scientific, ethical and religious movements of medieval and modern history, and to trace the causes of the success or failure of the movements to which these ideals have led. Christianity, including monasticism, modern Catholicism and Protestantism; medieval art and architecture; the modern scientific movement; and social and political democracy will be treated historically from this point of view. Lectures and reading; 3 hours. Credit, 3. Mr. Holcomb.

LANGUAGES AND LITERATURE.

Professor Mills.

LANGUAGES AND LITERATURE: ENGLISH, JOURNALISM AND PUBLIC SPEAKING.

Associate Professor Neal, Professor Lewis, Assistant Professor Smith, Mr. Wattles, Mr. Prince, Miss Goessmann.

English.

Required Courses.

1, 2. Freshman English. — Composition; introduction to literature. Recitations, laboratory practice and lectures; theme writing; conferences. Text-book and laboratory manual, Neal's "Thought-building in Composition." Freshmen; 4 hours. Credit, 4.

Associate Professor Neal, Assistant Professor Smith, Mr. Wattles, Mr. Prince.

3, 4. Sophomore English. — Composition; literature. Prerequisite, Courses 2 and 3 respectively; sophomores; 2 hours. Credit, 2.

Professor Lewis and Miss Goessmann.

Elective Courses in English Language and Literature.

7. Expository Writing. — The principles of exposition, with exercises in composition. Subjects will be largely found in current events and contemporary thought, and treated editorially. A foundation course in more advanced composition, primarily for juniors but open to seniors; advised for those who plan to take Course 8. First given in 1912–13. Two hours, with a third hour at the option of the instructor. Credit, 2.

Mr. Wattles.

8. Expository Writing. — The principles of exposition with especial reference to technical writing, including the writing of bulletins; some attention also to the more popular exposition of scientific facts. Primarily for juniors but open to seniors. First offered in 1912–13. Two hours, with a third hour at the option of the instructor. Credit, 2.

Mr. Wattles.

9, 10. Cultural Reading. — Not given in 1912–13.

13. English Writers and Thought. — Studies, laboratory problems, readings, and reports in some period of English literature. Three hours. Credit, 3. Assistant Professor Smith.

14. English Writers and Thought. — As in Course 13. Three hours. Credit, 3.

15. Prose Masters of the Nineteenth Century. — A sympathetic study of the writings of Ruskin, Carlyle, Newman, Arnold and Stevenson. Junior and senior course; 3 hours. Credit, 3. Professor Lewis.

16. Poets of the Victorian Age: Browning, Tennyson and Arnold. — This course will deal especially with the ethical and religious ideals of these poets as expressed in their most serious poems. Junior and senior course; 3 hours. Credit, 3. Professor Lewis.

17. Advanced Composition and Literature. — The reading and study of writings that are typical of literary style or form, especially in description and narration, and the writing of exercises involving problems of the same general sort as those illustrated by the readings. A good deal of fiction will probably be read, of which more or less will be found in the novels and short stories of our own day. On this study will be based the work in composition. Primarily for seniors but open to juniors. Two hours, with a third hour at the option of the instructor. Credit, 2. Associate Professor Neal.

18. Advanced Literature. — This course varies from year to year. It will usually provide opportunity either for intensive study of great writers or for study of the historical development or the structure and characteristics of literary types. Three hours. Credit, 3. Associate Professor Neal.

Journalism.

[The courses in journalism emphasize rural journalism. They aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant the application of journalistic principles in getting and suitably presenting material adapted to the non-urban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. Members of the classes supply, under the head "The Bay State Ruralist," a feature page for the "Springfield Sunday Union." Members of all classes may be required to turn in copy regularly for such disposition as the instructor may determine, and must have free time for covering stories. Students wishing to proceed beyond elementary study are urged to consult with the instructor before making their election in other subjects for the junior-senior years, in order that the most helpful program of work may be arranged.]

Elective Courses.

1. Introduction to Journalism. — The foundation conceptions and aims of journalism; practice in the simple forms of journalistic writing. Prerequisite to all other work in journalism, and valuable also to students

preparing for practical farming, agricultural or general science, rural education, etc., as a vocation. Two hours, with a third hour at option of the instructor. Credit, 2.

Associate Professor NEAL, Assistant Professor SMITH.

2. REPORTING. — News-gathering and news-writing. This includes the gathering and presentation of industrial and agricultural information, campus news or other stories, as may be directed. Courses 1 and 2 are the foundation courses in journalism. Students admitted to 2 who have not had 1 will be required to do extra work. Two hours, with a third hour at the option of the instructor. Credit, 2.

Associate Professor NEAL.

3. JOURNALISTIC PRACTICE. — The gathering and preparation of material for publication. The class may be organized as a staff. Prerequisite, course 1 or its equivalent. Two hours, with a third hour at the option of the instructor. Credit, 2. Associate Professor NEAL.

4. JOURNALISTIC PRACTICE. — As stated under Course 3.

5. ADVANCED JOURNALISTIC PRACTICE. — Informal; students will be assigned work as editorial assistants or writers, or otherwise employed in some form of journalistic activity. Study of particular forms of journalistic writing, of special subjects and their journalistic presentation, of particular kinds of periodical, or of current topics may be directed, and the presentation of a thesis may be required. Hours to be arranged. Two hours. Credit, 1. Associate Professor NEAL.

6. ADVANCED JOURNALISTIC PRACTICE. — As stated under Course 5.

PUBLIC SPEAKING.

Required Courses.

1. FRESHMAN PUBLIC SPEAKING. — Freshman public speaking is required in either the first or the second semester at the option of the instructor. The course is concerned with the actual problems which confront the man who would speak convincingly and persuasively. Some attention is given to breath control and development of speaking voice, considerable attention to pronunciation and enunciation, and a large amount of attention to the preparation and delivery of extempore speeches. Text-book, Shurter's "Extempore Speaking," supplemented by lectures and discussions. Freshmen; 1 hour. Credit, 1. Mr. PRINCE.

2. FRESHMAN PUBLIC SPEAKING. — As stated under Course 1. Required of all freshmen who are not assigned to take Course 1.

8. OCCASIONAL ORATORY. — Exercises for voice and gesture; a study of the elements of vocal expression and action; speeches on assigned topics; prescribed reading; the preparation and delivery of a formal oration or two. It is especially recommended for those who desire to enter the Flint contest. Two hours. Credit, 2. Assistant Professor SMITH.

LANGUAGES AND LITERATURE: GERMAN.

Assistant Professor ASHLEY, Mr. JULIAN.

Required Courses.

1. ELEMENTARY GERMAN. — Grammar and composition; the reading of short stories, poems, plays, etc. Especial attention is given to oral questioning and answering in German, and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4. Mr. JULIAN.

2. ELEMENTARY GERMAN. — As stated under Course 1. Prerequisite, Course 1.

3. INTERMEDIATE GERMAN. — Rapid reading of selected works from Schiller, Goethe, Lessing and others; review of grammar and dictation in German; outside readings. Required of freshmen who present German for entrance and do not take French. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4. Assistant Professor ASHLEY.

3A. INTERMEDIATE GERMAN. — Rapid reading of prose works, such as Sudermann's "Frau Sorge," and dramas, such as "Wilhelm Tell" and "Die Journalisten." Required of sophomores who took Courses 1 and 2 as freshmen. Mr. JULIAN.

4. INTERMEDIATE GERMAN. — As stated under Course 3. Prerequisite, Course 3.

4A. INTERMEDIATE GERMAN. — As stated under Course 3A. Open to students who have completed German 3A; 3 hours. Credit, 3.

5. ADVANCED GERMAN. — Literary study of the classicists, — Schiller's "Wallenstein," Lessing's "Nathan der Weise," Goethe's "Iphigenia," etc.; collateral readings in German and class-room reports. Conducted in German. Prerequisite, Course 4. Sophomores; required of those who took German 3 and 4 as freshmen; open upon arrangement to other students; 3 hours. Credit, 3. Assistant Professor ASHLEY.

Elective Courses.

6. ADVANCED GERMAN. — As stated under Course 5. Sophomores; open upon arrangement to other students. Prerequisite, Course 5; 3 hours. Credit, 3. Assistant Professor ASHLEY.

7. MODERN GERMAN. — Reading of articles from the best modern German periodicals, such as "Ueber Land und Meer;" conversation and composition work based on text. "Ferien in Deutschland," prepared by instructor; 3 hours. Credit, 3. Assistant Professor ASHLEY.

8. MODERN GERMAN. — As stated under Course 7.

9. Scientific German. — Reading of modern magazine articles and works in German of a scientific nature. Different work assigned according to needs of individual students. Open to juniors who have completed Course 4A or more advanced work. Three hours. Credit, 3.
Assistant Professor Ashley.

10. Scientific German. — As stated under Course 9.

11. German Literature. — Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust," and one modern typical drama. Prerequisite, Course 6 or 10.
Assistant Professor Ashley.

12. German Literature. — As stated under Course 11.

LANGUAGES AND LITERATURE: FRENCH.

Assistant Professor Mackimmie, Mr. Harmount.

1, 2. Elementary French. — The essentials of grammar are rapidly taught. Thieme and Effinger's "French Grammar" will be used during the first semester. A large amount of reading is required. Required of freshmen presenting German for entrance who do not continue that language and have not studied French; open upon arrangement to other students. Freshmen; 4 hours. Credit, 4. Mr. Harmount.

3. Intermediate French (third year). — Training for rapid reading; the reading of a number of short stories, novels and plays; composition; reports on collateral reading from periodicals and scientific texts in the library. Required of freshmen who present two years of French for entrance and do not take German, and of sophomores who take Courses 1 and 2 as freshmen; open upon arrangement to other students; 4 hours. Credit, 4. Assistant Professor Mackimmie, Mr. Harmount.

4. Intermediate French. — As stated under Course 3, but not required of sophomores who take Courses 1 and 2 as freshmen. Prerequisite, Course 3. Assistant Professor Mackimmie.

5. Advanced French (fourth year). — A reading course; Balzac's "Eugenie Grandet" and "Le Père Goriot" and other masterpieces of the nineteenth century; Brunetière's "Honoré de Balzac" and Harper's "Masters of French Literature;" readings in the library and written reports. Required of sophomores who take Courses 3 and 4 as freshmen; open upon arrangement to other students. Prerequisite, Course 4; 3 hours. Credit, 3. Assistant Professor Mackimmie, Mr. Harmount.

Elective Courses.

6. Advanced French (fourth year). — A general view of the history of French literature; Kastner and Atkins' "History of French Literature." Several plays of the great classical dramatists will be read. Individual

conferences on outside reading selected by the student. Prerequisite, Course 5. Sophomores; open upon arrangement to other students; 3 hours. Credit, 3. Assistant Professor MACKIMMIE.

7, 8. SCIENTIFIC FRENCH. — This course is planned to meet the requirements of the individual student and aims to equip him with exact English equivalents for the French scientific terms in his particular science. Word lists of scientific terms will be required and also weekly readings and reports from scientific works in the subject in which he is majoring. Several scientific readers will be read. Three hours. Credit, 3. Mr. HARMOUNT.

9, 10. MODERN FRENCH LITERATURE. — The outline is intended as a suggestion. The exact subject matter of the course will be determined when the men are enrolled. The object of this course is to give an introduction to recent movements in French literature. In the drama, readings from Augier, A. Dumas, fils, Delavigne; in the novel, from Flaubert, the de Goncourts, Zola; in criticism, from Taine, Renan, Sainte-Beuve; for the literary history of the period Lanson's "Histoire de la Litterature Française." Prerequisite, the required French. Juniors or seniors; 3 hours. Credit, 3. Assistant Professor MACKIMMIE.

LANGUAGES AND LITERATURE: SPANISH.

Assistant Professor MACKIMMIE.

Elective Courses.

1. ELEMENTARY SPANISH. — Grammar, with special drill in pronunciation; reading from a simple reader. Seniors or juniors; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor MACKIMMIE.

2. MODERN SPANISH AUTHORS. — Reading from modern Spanish novel and drama. Prerequisites, Course 1. Seniors or juniors; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor MACKIMMIE.

LANGUAGES AND LITERATURE: MUSIC.

Assistant Professor ASHLEY.

Elective Courses.

1. HISTORY AND INTERPRETATION OF MUSIC. — History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school — Bach, Händel, Haydn, Gluck and Mozart. One hour. Credit, 1. Assistant Professor ASHLEY.

2. HISTORY AND INTERPRETATION OF MUSIC. — A continuation of Course 1. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera. The Modern school and Modern composers. One hour. Credit, 1.
Assistant Professor ASHLEY.

DIVISION OF RURAL SOCIAL SCIENCE.

President Butterfield.

AGRICULTURAL ECONOMICS.

Associate Professor Cance.

Required Courses.

2. Agricultural Industry and Resources. — A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions. Sophomores; 3 hours. Credit, 3. Associate Professor Cance.

Elective Courses.

4. Elements of Agricultural Economics. — This course is designed to follow the required work in the elements of economics. It will consider the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; determination of price; speculation; problems of land tenure and land values; taxation of land values; the maintenance of the economic status of the farmer; and the relation of the farmer to the State. Lectures, text, readings, topics and field work; 3 hours. Credit, 3. Associate Professor Cance.

5. Historical and Comparative Agriculture. — Recommended to students in journalism or education. A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on present conditions and the history of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Seniors and juniors; open to other students upon arrangement; prerequisite, Course 4 or equivalent; 3 hours. Credit, 3. Associate Professor Cance.

6. Co-operation in Agriculture. — The course contemplates a somewhat comprehensive view of the history, principles and business relations of agricultural organization for profit. (1) A survey of the development and progress, the methods and economic results, of the farmers' organizations and great co-operative movements in the past; (2) the phases of business organization of agriculture abroad, and the present aspects and

tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, and practical working plans for co-operative associations, with particular reference to the marketing of perishable products. Lectures, text, assigned reading and practical exercises; 2 or 3 hours. Credit, 2 or 3. Associate Professor CANCE.

7. PROBLEMS IN AGRICULTURAL ECONOMICS. — An advanced course for students desirous of studying more intensively some of the problems immediately affecting the welfare of the farmer and society. Some of the problems that may be studied are: land problems, — land tenure, size of farms, causes affecting land values, private property in land, taxation of farm values, special problems, — cost of producing farm products, farm labor in New England, immigration, shifting of the rural population. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest. Seniors and juniors; open upon arrangement to other students; enrollment subject to approval of instructor; 2 or 3 hours a week. Credit, 2 or 3.
Associate Professor CANCE.

8. THE AGRICULTURAL MARKET. — This course contemplates a study of the forces and conditions which determine the prices of farm products, and the mechanism, methods and problems concerned with transporting, storing and distributing them. Such topics as supply and demand, course of prices, transportation by freight, express and trolley, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market, direct sales and the like will be taken up. The characteristics and possibilities of the New England market will be given special attention. Lectures, readings, assigned studies and field work. [Not offered in 1913–14.] Juniors and seniors; 2 or 3 hours a week. Credit, 2 or 3. Associate Professor CANCE.

9. SEMINAR. — Research in agricultural economics and history: New England agriculture to 1860. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged. Credit, 1.
Associate Professor CANCE.

10. SEMINAR. — As stated in Course 9.

AGRICULTURAL EDUCATION.

Professor HART, Associate Professor MORTON.

Elective Courses.

1. MEANING OF EDUCATION (PSYCHOLOGY). — A study of the development, structure and function of the nervous system with reference to the sense organs; relation of mind to the nervous system; growth and nature of mental processes; the activities of the mind in the process of learning. Text-book, lectures, discussion, and collateral readings and reports; 3 hours. Credit, 3. Professor HART.

2. VOCATIONAL EDUCATION (HISTORY AND PHILOSOPHY). — A survey of educational, religious and social movements with reference to their vocational aspects; the growth of educational institutions as influenced by science and industry. Lectures, collateral readings, reports, and a thesis on some phase of industrial education; 3 hours. Credit, 3.

Professor HART.

3. RURAL SCHOOL PROBLEMS. — A study of agricultural education; the theory and practice of teaching; school organization and methods of instruction; the place and function of agriculture in the course of study. Primarily for those who have had Course 1 or 2; 2 hours. Credit, 2.

Professor HART.

4. RURAL SCHOOL PROBLEMS. — Designed primarily for those who intend to teach; may be taken in connection with Course 3. The work consists of the selection and review of such parts of the courses in agriculture, horticulture and the biological and physical sciences as are adapted to the work of the public schools; planning, and practical work in school gardens; decoration of school grounds; equipment and conduct of playgrounds. One lecture period, 2 two-hour laboratory periods. Credit, 3.

Professor HART, Associate Professor MORTON.

5. SEMINAR IN EDUCATION. — For students who have had courses 1, 2 and 3, or an equivalent. Topics that may be taken up for rather exhaustive study are: rural school supervision, and rural school surveys, and secondary school agriculture. Seniors and graduate students; 2 hours. Credit, 2. Professor HART.

6. SEMINAR IN EDUCATION. — As stated under Course 5.

RURAL SOCIOLOGY.

Associate Professor EYERLY, President BUTTERFIELD, Professor HART, Mr. HOLCOMB.

Elective Courses.

2. THE RURAL COMMUNITY. — A broad survey of the field of rural sociology, including such topics as the movements of the rural population, the social conditions and life of rural people, the influence of rural life, the description of the various social institutions of the rural community, an analysis of the fundamental problems of rural life, and the means of developing and redirecting the life of the rural community. Lectures, readings and essays on assigned topics; 3 hours. Credit, 3.

President BUTTERFIELD and Associate Professor EYERLY.

3. THE LITERATURE OF RURAL LIFE. — A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities; 3 hours. Credit, 3. Mr. HOLCOMB.

4. Rural Law. — The work of this course will cover such points as land titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures, and class discussions; 1 hour. Credit, 1. Professor Hart.

5. The Social Conditions of the Rural People. — Composition of the rural population; vital statistics; nature, extent and causes of diseases and accidents; health agencies of control; extent and causes of delinquency and dependency; conditions of temperance, of sexual morality and family integrity; child labor; woman's work and position; relation of employer to employee; standard of living; size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics; 3 hours. Credit, 3. Associate Professor Eyerly.

6. Sociological Aspects of Co-operation among Farmers. — An historical sketch of the origin, extent and success of co-operation among farmers in the various European countries and in the United States; personal qualities and social conditions necessary to successful co-operative endeavor; the various forms of co-operative organization viewed in their industrial, intellectual and moral aspects; the influence of co-operation on the farmer's individualism, conservatism, self-help, thrift, contentment and on agrarian legislation, scientific agriculture and farm labor; the relation of co-operation to neighborhood life, to community pride and loyalty, to further associated effort, to class stability, solidarity and status; the demand of co-operation for a new type of leadership; the relation of co-operation to socialism and the competitive system; 3 hours. Credit, 3. [Given in 1912–13; not given in 1913–14.]
Associate Professor Eyerly.

7. Rural Institutions. — A study of the organized agencies by which rural communities carry on their various forms of associated life; particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment. Special attention given to the rural family and the rural church; 3 hours. Credit, 3. Associate Professor Eyerly.

8. The State and the Farmer. — A general survey of political organizations and movements among farmers in foreign countries and their influence in shaping agrarian legislation; the character, extent, and results of foreign State aid to the farming class; political movements among farmers in the United States; "Granger" legislation; relation of the Department of Agriculture, State boards of agriculture, agricultural colleges and experiment stations, postal system, railway commissions, highway commissions, public health agencies, etc., to rural welfare; 3 hours. Credit, 3. Associate Professor Eyerly.

9. The Social Psychology of Rural Life. — Characteristics of the rural mind; character of hereditary and environmental influences; nature and effects of face-to-face groups; psychological effects of isolation, rela-

tive security and freedom from strain; relation of contact with nature, of control over immediate environment, of family co-operation and of neighborhood life to self-control, self-expression, sympathy, service and leadership; nature and effects of fashion, conventionality and custom; character of discussion and public opinion, and their relation to class feeling and organization; relation of individualism, conservatism and homogeneity to crowd phenomena and progressive democracy; 3 hours. Credit, 3.
Associate Professor EYERLY.

10. FARMERS' ORGANIZATIONS. — The history, purposes and achievements of the Grange, the Farmers' Union, farmers' clubs, village improvement associations, boys' clubs, etc.; the nature, scope, methods and history of local, State and national associations formed about some farm product or special farm interest, *e.g.*, dairying, horticulture, stock breeding, forestry; their influence on "better farming, better business, better living;" their influence in forming a class consciousness and in shaping legislation; need of federation; 3 hours. Credit, 3. Associate Professor EYERLY.

11. SOCIOLOGICAL ASPECTS OF CURRENT AGRICULTURAL QUESTIONS. — Government conservation policy, roads, railways, trolleys, telephones, postal service, credit facilities, taxation, pure food laws, tenancy and ownership, intensive versus extensive farming, agricultural labor; 3 hours. Credit, 3.
Associate Professor EYERLY.

13. SEMINAR. Associate Professor EYERLY.

GENERAL DEPARTMENTS.

MILITARY SCIENCE AND TACTICS.

Captain MARTIN, Mr. PARSONS.

[The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement: —

All candidates for a degree in a four-years course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical (drill) courses in Military Science are given up to the Christmas recess and from the close of the spring recess to the end of the semester each year; the corresponding courses in Physical Education occupy the intervening time.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offences of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

The required uniform is of khaki, costing about $15. It is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit $15 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.]

Required Courses.

1. FRESHMAN DRILL. — Practical instruction in infantry drill regulations through the school of the battalion in close and extended order; advance and rear guards; outposts; marches; ceremonies; guard duty. Upon the conduct and proficiency of this year depends the appointment of corporals for the ensuing year. Freshmen; first semester until Christmas recess; 3 hours. Credit, 1. Captain MARTIN, Mr. PARSONS.

2. FRESHMAN DRILL. — As stated under Course 1. Freshmen; second semester after spring recess; 3 hours. Credit, 1.

3. Sophomore Drill. — Practical instruction as before; pointing, aiming and sighting drills; litter drills, and first aid to the injured by detachment; target practice, in gallery and on the range. Corporals are appointed from this class. On their conduct and proficiency depends the appointment of sergeants in the next class. Sophomores; first semester until Christmas recess; 3 hours. Credit, 1. Captain Martin, Mr. Parsons.

4. Sophomore Drill. — As stated under Course 3. Sophomores; second semester after spring recess; 3 hours. Credit, 1.

5. Sophomore Tactics. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the company, "Manual of Guard Duty," "Small Arms Firing Regulations." Sophomores; 1 hour. Credit, 1. Captain Martin.

6. Sophomore Tactics. — As stated under Course 5. Sophomores; 1 hour. Credit, 1.

7. Junior Drill. — Practical instruction as before, target practice, in gallery and on the range. Sergeants are appointed from this class. On their conduct and proficiency depends their selection as officers for the ensuing year. When necessary, officers will also be appointed from this class. Juniors; first semester until Christmas recess; 3 hours. Credit, 1. Captain Martin, Mr. Parsons.

8. Junior Drill. — As stated under Course 7. Juniors; second semester after spring recess; 3 hours. Credit, 1.

9. Junior Tactics. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the battalion; advance and rear guards; outposts; marches and ceremonies; "Manual of Field Service Regulations;" preparation of reports; returns, muster-rolls, enlistment and discharge papers, rosters, requisitions, etc.; army regulations; lectures on military science. Juniors; 1 hour. Credit, 1. Captain Martin.

10. Junior Tactics. — As stated under Course 9. Juniors; 1 hour. Credit, 1.

Elective Courses.

11. Senior Drill. — Practical instruction as before; conduct of drills of lower classes. Officers will as a rule be selected from this class. Cadets electing Courses 11 and 12 must take the election for the year, and not later than the first Monday in June of their junior year. No cadet electing this course will after the commencement drill be permitted to change his election without the consent of the dean of the faculty and of the commandant. Seniors; first semester until Christmas recess; 3 hours. Credit, 1. Captain Martin.

12. Senior Drill. — As stated under Course 11. Seniors; second semester after spring recess; 3 hours. Credit, 1.

PHYSICAL EDUCATION AND HYGIENE.

Assistant Professor HICKS, Mr. FITZMAURICE.

HYGIENE.

Required Courses.

1. HYGIENE. — Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation. Freshmen; 1 hour. Credit, 1.
Assistant Professor HICKS.

PHYSICAL EDUCATION.

[The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in Military Science. All classified undergraduate students are given a physical examination upon entering.]

Required Courses.

1. ELEMENTARY GYMNASTICS. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 2. Freshmen; 3 hours. Credit (given only for Course 2), 1.
Assistant Professor HICKS and Mr. FITZMAURICE.

2. ELEMENTARY GYMNASTICS. — As stated under Course 1.

3. GRADED GYMNASTICS. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 4. Sophomores; 3 hours. Credit (given only for Course 4), 1.
Assistant Professor HICKS and Mr. FITZMAURICE.

4. GRADED GYMNASTICS. — As stated under Course 3.

5. GYMNASTICS. — Drills, games and athletics; from January 1 to April 1, in connection with Course 6. Juniors; 3 hours. Credit (given only for Course 6), 1. Assistant Professor HICKS and Mr. FITZMAURICE.

6. GYMNASTICS. — As stated under Course 5.

Elective Courses.

7. TRAINING COURSE. — Leadership class and squad work; supervision of indoor and outdoor athletic contests and games; boxing and wrestling. Seniors; 3 hours. Credit, 1. Assistant Professor HICKS.

8. TRAINING COURSE. — As stated under Course 7.

THE GRADUATE SCHOOL.

THE GRADUATE SCHOOL.

KENYON L. BUTTERFIELD, A.M., LL.D., President of the College.

CHARLES E. MARSHALL, Ph.D., Director of the Graduate School and Professor of Microbiology.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years. Demands for these courses have now greatly increased, and in recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station agriculturists, bacteriologists, botanists, chemists, entomologists, horticulturists and zoölogists; and for numerous other positions requiring a great degree of skill and scientific knowledge.

ADMISSION.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.
2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the professor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for membership to the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, — together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

Nature and Methods of Graduate Work.

Persons taking graduate work will find this quite different in its nature from undergraduate courses. A broad knowledge of two (or three) subjects is required, and the professors in charge of these may adopt any methods which may seem desirable to secure this to the student. Lectures, laboratory and field work in various forms are utilized; but whatever the method chosen, the aim is to train the students in methods of original investigation and experiment, inductive reasoning and the ability to carry on independent research. In addition to the lectures, a large amount of outside reading is required, the object being to give a broad knowledge of all aspects of the subjects chosen, in addition to the complete knowledge of those portions involved in or directly related to the original investigation which is to result in the thesis. Originality and ability to lead in scientific research after completing graduate work, and the establishment of a broad and thorough foundation upon which these qualities must be based, are the objects aimed at; and any methods which promise to give these results may be made use of (varying according to the nature and personal equation of each student), the supervision being largely individual rather than collective.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as the major and the other as the minor. These subjects may not be selected in the same department.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major, the others as minors. No two of these subjects may be taken in the same department.

Advanced students who are not candidates for degrees may, with the approval of the faculty of the school, take more than one subject in the same department.

A statement of the subjects chosen must in each case be submitted to the director of the school for approval by the necessary committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

A description of the equipment of the various departments is given under "General Information."

Theses.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject, must show that its writer possesses the ability to carry on original research, and must be an actual contribution to knowledge.

Two copies of each thesis in its final form, ready for the printer, must be submitted to the director of the school before the candidate for the degree may take the required oral examination. One of the said copies, to contain all drawings, is to be retained as an official copy by the said director, and the other by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis. When printed, three copies of each thesis must be deposited with the director of the graduate school and three copies with the department in which the work was carried out.

All theses become the property of the department in which they are prepared.

FINAL EXAMINATIONS.

For the degree of master of science, a final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degree of doctor of philosophy, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

DEGREES CONFERRED.

The degree of master of science is conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence.
2. The devotion of twenty hours each week to the chief or major subject, and of from twelve to sixteen hours per week to the minor subject.
3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.
4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.
5. The payment of all fees and college expenses required.

The degree of doctor of philosophy is conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.
2. The devotion of twenty hours each week to the chief or major subject during the entire period, and of from twelve to sixteen hours per week for a year and a half to each minor subject.
3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.
4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the professors in charge.
5. The payment of all fees and college expenses required.

The fee for the degree of master of science is $10, and for the degree of doctor of philosophy, $25.

COURSES FOR DEGREE OF MASTER OF SCIENCE.

Available either as major or minor subjects for the degree of master of science: —

Agriculture.
Botany.
Chemistry.
Entomology.
Horticulture.
Mathematics and physics.
Veterinary science.
Zoölogy (minor only).

COURSES FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Available for a major subject for the degree of doctor of philosophy: —

Botany.
Chemistry.
Entomology.
Horticulture.

Available for a minor subject for the degree of doctor of philosophy: —

Agriculture.
Botany.
Chemistry.
Entomology.
Horticulture.
Zoölogy.

GENERAL OUTLINE OF COURSES FOR THE DOCTORATE.

Major Courses.

BOTANY. — The following subjects in botany may be studied: —

(*a*) Vegetable physiology.
(*b*) Vegetable pathology.
(*c*) Mycology.
(*d*) Ecology.
(*e*) Taxonomy.
(*f*) Phylogeny.
(*g*) History of Botany.
(*h*) History and theory of evolution.

These subjects are pursued, to a greater or less extent, as the previous training of the student and the nature of the original problem undertaken may determine. The object of the course is to give the student a technical training in botany, to develop the spirit of research and to lay a broad foundation in the subject. (As a supplement to this course the student will do well to take, in addition to his prescribed minor work, a brief course in the history of philosophy and psychology.) Extensive reading of botanical literature, both general and specific, is required in certain subjects, and occasional lectures are given. A botanical conference is held monthly, in which various new problems of botanical science are considered by graduate students and the seniors who elect botany. A thesis dealing with some economic problem in plant physiology or pathology, or in both, and containing a distinct contribution to knowledge, is required.

CHEMISTRY. — The department is prepared to offer advanced courses in the following branches of chemistry, particularly as applied to agriculture: —

(*a*) Inorganic chemistry.
(*b*) Organic chemistry.
(*c*) Physiological chemistry.
(*d*) Physical chemistry.
(*e*) Analytical chemistry.

Here follows a statement of courses which may be selected by any one properly qualified, and particularly by those who are desirous of doing work for advanced degrees: —

Course A. Research in industrial problems applied to agriculture.
Associate Professor PETERS.

Course B. Research in physico-agricultural chemistry. Prerequisite, Course 15 or its equivalent. Assistant Professor ANDERSON.

Course C. Advanced analytical chemistry. Research work in connection with the study of methods of analysis of fertilizers, cattle feeds, dairy products, soils, insecticides and sugars. Recent and original methods will be applied to a study of the composition of agricultural products. Professor WELLINGTON.

Course D. Advanced organic chemistry. Special topics in advanced organic chemistry will be considered, both by lectures and in the laboratory. These will include such subjects as constitution and properties of carbohydrates, proteins and fats, uric acid and related compounds, and alkaloids; also such purely chemical phenomena as isomerism, tautomerism and optical rotation. The reading will include "The Monographs on Biochemistry," Cohen, Schorlemmer and Lachman. Associate Professor CHAMBERLAIN.

Course E. Advanced topics in physiological agricultural chemistry will be studied especially in the laboratory, including digestion, metabolism and nutrition, dietetics, feeding rations, enzymatic action and isolation of enzymes. Required reading will be followed in Abderhalden, Lusk, Hammersten, Stiles, Armsby and Euhler. Associate Professor CHAMBERLAIN.

Students for the advanced degrees of master of science and doctor of philosophy will be given a special outline of work, and will also be assigned a subject for an original thesis by the professor in charge of the work, all of which must be completed to the satisfaction of the chemical staff and particularly of the professor under whom the work is done. Students not working for a degree may take special work along agricultural chemical lines. Information may be obtained by consulting the chemical staff.

ENTOMOLOGY. — I. For the degree of doctor of philosophy as a major: Some knowledge of all the divisions of this subject is essential for the professional entomologist, though a large part of his time will be devoted only to certain portions. To insure some familiarity with all these divisions, lectures, laboratory work, field training or required reading are given in each of the following topics: —

(*a*) *Morphology.* — Embryology; life history and transformations; histology; phylogeny and the relation of insects to other arthropods; hermaphroditism; hybrids; parthenogenesis; pedogenesis; heterogeny; chemistry of colors of insects; luminosity; deformities of insects; variation; duration of life.

(*b*) *Ecology.* — Dimorphism; polymorphism; warning coloration: mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migration; geological history of insects; insects as disseminators of disease; enemies of insects, vegetable and animal, including parasites.

(*c*) *Economic Entomology.* — General principles; insecticides; apparatus; special cases; photographs of insects and their work; methods of drawing for illustrations; field work on insects and study of life histories; legislation concerning insects.

(*d*) *Systematic Entomology.* — History of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, how to find and use it; indexing literature; number of insects in collections and in existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

(*e*) *Seminar.* — A monthly meeting of graduates, at which reports on current literature are presented and various entomological topics of importance are discussed.

(*f*) *Required Readings.* — The best article on the various topics named above and on the different orders of insects, to cover from fifteen thousand to twenty thousand pages of English, French and German, the candidate to be examined at the close of his course on this with his other work.

(*g*) *Thesis.* — A thesis, illustrated with drawings, consisting of the results of original investigation upon one or several topics, and constituting a distinct contribution to knowledge, must be completed before the final examinations are taken.

II. For the degree of doctor of philosophy as a minor, and for the degree of master of science either as a major or minor: Such portions of the course outlined above as seem most appropriate to their other subjects are given to students taking entomology as a minor.

HORTICULTURE. — Graduate work is offered in various lines of horticulture. For the most part this is divided into the different departments which now constitute the college Division of Horticulture, and which are as follows: Pomology, Floriculture, Landscape Gardening, Forestry and Market Gardening. For work in these lines application should be made direct to the heads of the several departments.

Besides this work, however, opportunity is offered for graduate study in General Horticulture, including topics from the several organized departments mentioned, and also questions relating to plant breeding, general evolution, propagation, manufacture of horticultural products, etc. This general work is under the direction of Prof. F. A. Waugh, head of the Division of Horticulture.

ZOÖLOGY. — Courses in zoölogy are available as a minor for the degree of master of science, and as a minor for the degree of doctor of philosophy. The nature of the work varies according to circumstances, and may be intensive in a special field, or of a somewhat more general character, depending on the student's previous acquaintance with general zoölogical science.

The time devoted to zoölogy as a minor for either of the above-named degrees may vary from 12 to 16 hours per week, pursued for a year and a half.

THE SHORT COURSES
AND
THE EXTENSION SERVICE.

THE SHORT COURSES AND THE EXTENSION SERVICE.

The Short Courses and the Extension Service.

Through its Extension Service, the Massachusetts Agricultural College attempts to make every department of the institution a contributing factor toward developing the agriculture and country life of the Commonwealth. The work of the Extension Service divides itself quite naturally into the Short Courses given at the college and the various activities of an educational nature which are carried on all over the State.

Under the usual definition of extension activities, Short Courses are not strictly extension projects. They are rather a part of the academic work of the institution. For the sake of administrative efficiency it has seemed best to place them in charge of the director of the Extension Service in so far as organization and direction are necessary. An effort is made through these courses to bring to the college, for a few days or a few weeks, as many people as can possibly be reached in this way. In the main, the instruction in the Short Courses is given by the regular teaching force of the college, the same laboratories and equipment being used for this work as in the regular college work.

The Extension Service proper comprises various methods for the dissemination of agricultural information to the people of the Commonwealth who are interested in agriculture and country life, but who cannot come to the college for even a short time. The object of the Extension Service is to make the college as useful to the people of the Commonwealth as possible.

A. THE SHORT COURSES.

ORGANIZATION AND DESCRIPTION.

The work is organized thus: —

Short Courses given at the College.
1. Winter School.
    - (*a*) Ten Weeks' Winter Course.
    - (*b*) Apple Packing School.
    - (*c*) Farmers' Week.
    - (*d*) Beekeepers' Course and Conference.
    - (*e*) Poultry Conference.
2. Summer School.
    - (*a*) The Summer School (General Course).
    - (*b*) Conference for Rural Community Leaders.

EXPENSES IN THE SHORT COURSES. — The expense of attending any of the Short Courses will be about as follows: —

Registration fee,	$5
Furnished rooms in private houses,	$1.50–$3
Board at college dining hall, per week,	$4
Board with private families, per week,	$5–$6

It is expected that a lunch counter will be operated in connection with the college dining hall. Meals may be obtained there *à la carte* at very reasonable prices.

Students in each of the dairy courses must provide themselves with two white wash suits and a white cap for use in the practical dairy work. The cost in Amherst is about $1.25 for suit and cap.

REQUIREMENTS FOR ADMISSION TO SHORT COURSES. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic. Practical experience in farm, garden, orchard or greenhouse work will be an advantage. The courses are open to both men and women.

Students must be at least eighteen years of age and must furnish satisfactory evidence of good moral character. References are required and these are investigated before applicants are accepted.

Winter School.

COURSES IN THE TEN WEEKS' WINTER SCHOOL (JAN. 6 TO MARCH 14, 1913). — The following courses were given: —

1. Soil Fertility. Associate Professor HASKELL. Three periods a week for ten weeks.
2. Field Crops. Mr. E. M. MCDONALD. Three periods each week for ten weeks.
3. Breeds and Breeding. Associate Professor MCLEAN and Mr. QUAIFE. Three one-hour and two two-hour periods each week for ten weeks.
4. Feeding and Management. Associate Professor MCLEAN and Mr. QUAIFE. Two periods each week for ten weeks.
5. Dairying. Associate Professor LOCKWOOD, Mr. COONS and assistants. Three one-hour, two two-hour and two three-hour periods each week for ten weeks.
6. Dairy Bacteriology. Associate Professor LOCKWOOD. Two periods each week.
7. Animal Diseases and Stable Sanitation. Professor PAIGE. Two periods each week for ten weeks.
8. Poultry. Associate Professor GRAHAM. Five one-hour and two two-hour periods each week for ten weeks.
9. Fruit Growing. Professor SEARS. Four lectures and one laboratory period each week for ten weeks.
10. Market Gardening. Assistant Professor YEAW. Two periods each week for ten weeks.
11. Landscape Gardening. Mr. HARRISON. Two periods each week for ten weeks.
12. Floriculture. Professor WHITE. Five periods each week for ten weeks.
13. Forestry. Professor CLARK. One lecture a week for ten weeks.
14. Botany. Assistant Professor OSMUN and Mr. MCLAUGHLIN. Three periods each week.
15. Entomology. Professor FERNALD and assistants. Three periods each week for ten weeks.
16. New England Agriculture (required). Two periods a week for ten weeks.
17. Farm Buildings. Professor FOORD. One period a week for ten weeks.
18. Farm Accounts. Professor FOORD. Two periods each week for ten weeks.
19. Mechanics. Associate Professor LOCKWOOD and Mr. SCHROYER. Two periods each week for ten weeks.
20. Rural Sanitary Science. Assistant Professor GAGE. Two periods each week for ten weeks.
21. Beekeeping. Assistant Professor GATES. Two periods each week for ten weeks.
22. Rural Improvement. Professor WAUGH. One lecture each week for ten weeks.

APPLE PACKING SCHOOL. — The work of this school, which is conducted by the department of pomology, is of a practical nature and includes both box and barrel packing. Persons taking the course will become familiar with the various types of packs and will receive sufficient practice to enable them to do good commercial packing.

The work in packing is supplemented by lectures on phases of commerical orcharding, such as planting, varieties, spraying, pruning, harvesting and marketing.

A fee of $5 to help pay for fruit and other materials used is charged for this course.

FARMERS' WEEK. — In order to reach those who cannot come to the college for a longer time this very practical course, four days in length, is given each year. The regular college equipment is used and work of the regular faculty is supplemented by lectures and demonstrations given by eminent men.

The work is divided into four sections: (1) General agriculture, to include farm management, farm crops and so forth; (2) Dairying, animal breeding and feeding, poultry, veterinary science and bacteriology; (3) Horticulture, to include fruit growing, market gardening, floriculture and forestry; (4) Farmers' wives' section, including lectures and demonstrations in home economics, cooking and problems of homemaking.

Features of the week are the evening lectures by specialists along agricultural lines, the conference pertaining to problems of rural betterment aside from practical agricultural topics, a corn show, grain show, dairy show and so forth.

The Massachusetts Dairymen's Association and the Massachusetts Agricultural College Agricultural Improvement Association hold their annual meetings at the college during this week.

Complete programs of the 1914 Farmers' Week may be obtained in February, 1914.

BEEKEEPERS' COURSE. — In the last three years a complete apiary and equipment has been brought together at the college, under the direction and management of Dr. Burton N. Gates. This equipment furnishes the best of facilities for the teaching of beekeeping and allied subjects. A conference of beekeepers, with extensive exhibits of beekeepers' supplies and apparatus, is held annually at the close of each short course.

The courses offered in 1913 are: —

1. Practical Phases of Beekeeping. Associate Professor GATES.
2. Crops for Honey Bees. Dr. BROOKS.
3. Relation of Bees to the Pollination of Plants. Professor STONE.
4. Origin and Evolution of the Honey Bee. Professor FERNALD.
5. Bees and Beekeepers' Supplies. Professor PAIGE.

The features of the convention are lectures, demonstrations by authorities of national reputation, as well as exhibits of inventors, manufacturers, supply merchants and queen rearers. A special invitation is extended to all beekeepers to display and demonstrate inventions, implements or methods. If table space is desired or special equipment is to be prepared, notice should be sent to Dr. Burton N. Gates, Amherst, Mass., at least two or three weeks before the convention. The college provides covered tables for the exhibits.

POULTRY CONFERENCE. — In order to give a large number of poultrymen, who cannot come to the college for a longer time, practical instruction in modern methods of breeding, feeding, poultry-house construction, operation of incubators and brooders, selecting and judging poultry for utility and for show, marketing poultry products, and so forth, a convention lasting nearly a week is held each year. The regular date has been changed from the spring of the year to the summer, and the meeting will be held July 28–30, 1913.

The Summer School.

The Summer School of Agriculture of the Massachusetts Agricultural College, which was omitted in 1912, reopens July 1, 1913, for a term of five weeks. This is the sixth session of the summer school, those of 1907 to 1911 having been highly successful. The experience of these five years will aid in making material improvements in the session of 1913.

The work of the summer school was designed originally for school teachers. The attendance has been largely of that class, and special attention will be given to the needs of teachers each year. It has been found, however, that there are many others who seek a general knowledge of theoretical and practical agriculture, and who can come to the college conveniently during the summer season. Extended courses are offered for the benefit of such persons also.

The following courses will probably be offered in 1913: —

Soils and tillage, field crops, domestic animals, dairying, poultry husbandry, fruit growing, practical gardening, trees and shrubs, forestry, landscape gardening, elementary chemistry, agricultural chemistry, plant life, cryptogamic botany, bird life, insect life, entomology, beekeeping, home economics, domestic science, home and school gardening, high school agriculture, home floriculture, agricultural economics, rural sociology, rural literature, agricultural education, organized play and recreation, arts and crafts.

From these courses it will be possible to make up programs of work suitable to the needs of almost every one, but especially of school teachers, principals, superintendents, school committeemen, farm owners, householders, suburban residents, clergymen, pastors, preachers, social workers and those who have a general interest in agriculture. Persons who are in doubt as to what courses will best suit their needs had better correspond with the Director of the Extension Service, who will gladly advise in all such matters.

Special courses covering two weeks are offered especially for clergymen, librarians and other rural leaders.

General Plan. — From the courses offered, each student may elect courses amounting to not less than ten nor more than fifteen exercises a week, unless a larger or smaller amount of work is permitted by the director. These courses include a large amount of field work, observation trips, outdoor exercises and laboratory experiments.

Besides these, general field exercises are arranged for one afternoon each week. These are on topics of interest to all. Class excursions are arranged for every Wednesday afternoon, and more extended excursions for the whole school are conducted every Saturday. These are personally conducted by members of the faculty.

Round tables and special discussions are arranged by various instructors as their courses require.

A course of evening lectures on popular topics relating to the work of the school are a feature of the general program. Several able lecturers are engaged each year for this course. No admission is charged for these lectures.

The expenses are low. Amherst is situated in one of the most noted historical and educational centers in this country. Any one interested in problems pertaining to country life should not fail to attend. A descriptive bulletin can be had March 1, 1913.

CONFERENCE OF RURAL LEADERS. — The Annual Conference of Rural Leaders will be held July 30–August 2, as a closing feature of the summer school.

It is hoped the following organizations will co-operate as usual with the college by furnishing teachers and lecturers for their respective sections: the Federation of Churches of Massachusetts, the State Board of Education, the Free Public Library Commission, the Massachusetts Civic League, the State Board of Health, the County Work of the Young Men's Christian Association, the National Board of the Young Women's Christian Association, the New England Home Economics Association, the Russell Sage Foundation and the State Grange.

Definite class instruction will be given each morning. The afternoons will be given up entirely to special and general conferences, demonstrations of organized play, recreation and so forth. The evenings will be given over to music and lectures by the most eminent men who are making a study of rural sociology, economics and education.

The Rural Social Service exhibits will be more elaborate and extensive than in 1912.

The object of this conference is to acquaint those who are leaders in their respective communities with the work that is going on, not only in Massachusetts but in New England and other parts of the world, and to give them renewed inspiration and enthusiasm for larger and more intelligent efforts.

Teachers, clergymen, grange officers, librarians, county Y. M. C. A. workers, town officers, boards of health, officers of village improvement societies, homemakers, school officers, and all others interested in community development, are cordially invited to attend this conference. The expenses for board and room are low. There are no tuition or registration fees.

A complete program will be published in June, 1913, and can be had on application.

B. THE EXTENSION SERVICE.

ORGANIZATION AND DESCRIPTION.

1. Special Days for Foreigners, Agricultural Associations, etc..
2. Instruction given away from the College.
    (1) Correspondence Courses.
    (2) Lecture Courses and Demonstrations.
    (3) Conferences for Community Development.
    (4) Extension Schools of Agriculture.
    (5) Educational Trains (Steam and Trolley).
    (6) Educational Exhibits, with Lectures and Demonstrations at Fairs.
    (7) Demonstration Orchards.
    (8) Dairy Improvement Associations.
    (9) The Massachusetts Agricultural College Agricultural Improvement Association.

(10) Agricultural Surveys.
(11) Advisory Work with State Institutions, Individuals, etc.
(12) Publications, "Facts for Farmers," etc.
(13) Student Extension Work.
(14) Faunce Demonstration Farm.
(15) Boys' and Girls' Clubs.
(16) Demonstration Plots.
(17) Traveling Libraries.
(18) Co-operation with various organizations already in existence.
(19) District Field Agents.
(20) Information by Correspondence, etc.

1. *Special Days for Foreigners, Associations, etc.*

Days are set aside for special attention to the interests of foreigners, of agricultural organizations, etc.

AGRICULTURAL ORGANIZATIONS. — It has been especially pleasing to the college to have organizations such as the Massachusetts Poultry Association, the Massachusetts Fruit Growers' Association, Market Gardeners' and Breeders' associations, and others, meet frequently at the college. Usually a program of one or two days is provided, largely by the college faculty. These meetings serve the twofold purpose of giving the members of these organizations a chance to inspect the equipment and see the work that is being carried on by the college, and it also gives the college men a chance to find out the needs of the men engaged in the various lines of agriculture. It is hoped that other organizations besides those mentioned above will also meet at the college and that meeting will be even more frequent than in the past.

POLISH FARMERS' DAY. — In order to show the Polish farmer — who forms a large part of the population of this section of the Connecticut valley — what the college has to offer him, a Polish Farmers' Day is held each year with much success. Members of the faculty give lectures which are interpreted by Mr. K. J. Wolski of Holyoke; some of the Polish farmers who have made a success of farming also give talks. The Immigration Department of the State, the Y. M. C. A. and the Polish American Alliance co-operate with the college in this work.

2. *Instruction given away from the College.*

An abstract follows of the instruction that is given away from the college. The abstract divides this instruction into correspondence courses and instruction not included in the correspondence course.

CORRESPONDENCE COURSES. — The correspondence courses are offered by the college in response to calls from all sections of the State from people who desire agricultural information, but who cannot come to the college for it. The courses are designed to meet the needs of farmers, dairymen, stock breeders, fruit growers, market gardeners, floriculturists and teachers in elementary schools, high schools, academies or normal schools.

Since agricultural science and practice are changing so rapidly, it is the purpose to give a summary of the latest information on the subjects treated, yet in such language that any who pursue the study can readily understand the work. Additional courses, covering other subjects, will be added from year to year.

Method of Conducting Correspondence Work. — While a large number of books have been written on various agricultural subjects, very few of them are especially adapted to the correspondence course work. For this reason our courses are conducted principally by specially prepared lessons. The subject-matter partakes somewhat of the lectures that are given to the college classes. Whenever possible we recommend one or two books which ought to be purchased and read along with the course. Other books are recommended for collateral reading, which oftentimes can be obtained from the local libraries.

The courses are especially recommended to the Y. M. C. A. and to granges and other farmers' clubs for study. It is to be hoped that grange lecturers, club secretaries, and other interested persons, will organize study classes. If the size of the class, or the interest which the members take in the subject, is sufficient, we shall be pleased to send a representative of the college to the class from time to time to discuss the work and offer suggestions. A description of the correspondence courses follows: —

1. Soil and Soil Improvement. Director HURD.
2. Manures and Fertilizers. Director HURD.
3. Field Crops. Associate Professor HASKELL.
4. Farm Dairying. Associate Professor LOCKWOOD.
5. Fruit Growing. Professor SEARS and Mr. REES.
6. Market Gardening. Assistant Professor YEAW.
7. Animal Feeding. Mr. STORY.
8. Floriculture. Professor WHITE. Part I. The general culture of plants, including those grown out of doors as well as those grown under glass. Part II. Greenhouse construction and heating. Part III. Carnation culture. Part IV. Rose culture. The cost of each part, not including the text-book, is $1.
9. Farm Accounts. Professor FOORD.
10. Entomology. Professor FERNALD.
11. Agricultural Education. Professor HART.
12. Beekeeping. Assistant Professor GATES.
13. Forestry. Professor CLARK.
14. Shade Tree Management. Professor STONE.
15. Agriculture in the Elementary Schools. Associate Professor MORTON.
16. Community Co-operation in Elementary Education. Associate Professor MORTON.
17. Poultry Husbandry. Associate Professor GRAHAM. (Will be ready February, 1913.)

Enrollment for Correspondence Courses. — Students may enroll in the courses any time between September 1 and June 1 of the following year. It has been found advisable not to continue the courses through the summer because the farmers as well as the other students are so busy that they cannot spend the necessary amount of time upon the lessons during the summer months. We are better equipped than we were last year to handle the great number of students who desire these courses, and we hope to be able to take care of all the students who enroll. An early enrollment is advised, however.

Enrollment must be made on the card which is furnished by the college. This will entitle the student to a suitable set of covers and other privileges.

Expenses of the Correspondence Courses. — In order that none may enroll but those who are interested and desire to pursue earnest study, a small fee is charged. This has been fixed at the uniform rate of $1 for each course, except in Course 8, where it is necessary to charge $1 for each of the four parts, as each part is really a course in itself. This fee is payable strictly in advance when the enrollment card is sent, and the first lesson of the course will not be sent until the fee is received.

This fee is not charged to cover cost of preparing the course, for this, in time of the instructors, is many times what is received, but it is used to defray the expenses of postage and materials which are used in preparation of the lessons, and to insure a higher quality of work from those who enroll.

The cost of the text-book, when one is used, is in addition to the enrollment fee. We strongly urge all students to purchase one or two books to be used in connection with each course, because they can be kept and used for reference purposes after the course is completed. We have made arrangements with the Johnson Book Company, Amherst, Mass., to handle all of these books at reduced rates. For a catalogue of books and prices, address the Johnson Book Company. Remittances should be made by money order or check.

LECTURE AND DEMONSTRATION COURSES AWAY FROM THE COLLEGE. — The renewed and unprecedented interest in agriculture and rural life makes many more calls on the college for lectures and demonstrations than can be met. These calls come from all sorts of organizations, and the audiences are usually of good size and composed of interested people, who are eager to get the latest scientific information to use in their work. A list of lectures and their subjects can be obtained upon request.

EXTENSION SCHOOLS OF AGRICULTURE. — The extension schools held by the college during the past year were most successful, and many applications are being received for schools during 1912–13. An effort is being made so to locate these schools that they may best serve the people of the whole State. Valuable features are being added, and the work will be kept up to the highest possible standard.

EDUCATIONAL EXHIBITS, LECTURES AND DEMONSTRATIONS AT FAIRS. — During the past year lectures and demonstrations were given at sixteen fairs throughout the State. It is expected that during the next year a new college exhibit will be prepared which may be loaned to the fairs and other organizations which ask for an exhibit each year. Aside from the lectures and demonstrations which were given, successful stock judging contests were held under the direction of the college at 13 fairs.

DEMONSTRATION ORCHARDS. — During 1912, 2 new orchards have been planted and 1 orchard renovated, making a total of 10 new orchards and 4 renovated orchards now under the direction of the college. Three new orchards have been promised for the spring of 1913.

DAIRY IMPROVEMENT ASSOCIATIONS. — At the present time three associations have been organized. Others will be started as competent official testers can be found.

THE MASSACHUSETTS AGRICULTURAL COLLEGE AGRICULTURAL IMPROVEMENT ASSOCIATION. — This is an organization largely of graduates and ex-students of the college, banded together for the purpose of agricultural betterment in Massachusetts. There are at the present time about 136 members, 30 of whom are taking active part in the producing of high-class seed corn and seed potatoes, and in demonstrating the possible improvement of worn out pastures.

The usefulness of this association in the State will depend almost wholly upon the energy with which the members enter into the plans worked out by the executive committee of the association. That great things are possible for the association is shown by the work done by similar associations in other States.

AGRICULTURAL SURVEYS. — Through these surveys an attempt is made, by systematic study, to find out the exact conditions of farm management, including dairying, orcharding, poultry raising and other specialties, the income which is derived from these, and the facilities for marketing products. An inquiry into the social, educational, religious and moral life of rural communities is also made.

ADVISORY WORK WITH STATE INSTITUTIONS, INDIVIDUALS, ETC. — For the past two years special effort has been made to comply with the requests of State organizations and individuals for advice. Visits have been made when possible, but it is impossible to comply with half of the requests which come in each year.

EXTENSION SERVICE PUBLICATIONS. — Each year bulletins and circulars descriptive of the various short courses are published. A monthly pamphlet, "Facts for Farmers," is also issued. It is the aim of this pamphlet to give timely information on agricultural subjects in a brief and simple manner. Articles on spraying, pruning, poultry, clean milk and so forth have been issued and are in great demand. Bulletins and "Facts for Farmers" will be sent to all who apply for them.

STUDENT EXTENSION WORK. — As would be expected in an institution which stands for agricultural improvement in its broadest sense, the students of the Massachusetts Agricultural College are eager to have a hand in the general work of community betterment carried on by the college staff. A large number of students are employed each year in the teaching of English to foreigners in towns located near Amherst, and in carrying on helpful meetings of a general nature throughout the western part of the State. Calls for this kind of work are many, and the willingness on the part of the students is increasing from year to year. Under efficient management this work promises to be very successful in every detail.

THE FAUNCE DEMONSTRATION FARM. — This farm, located at Sandwich, is under the direction of a committee from the college faculty, of which the Director of the Extension Service is chairman. The farm has demonstrated beyond a doubt that small fruits, vegetables and poultry can be raised at a profit on Cape Cod. Through the work of this farm the whole community has taken on new life. The superintendent of the farm, Mr. A. W. Doolittle, has taught agriculture in the schools of the village and has given much help to the farmers of Barnstable County by his personal visits to farms.

DEPARTMENT OF AGRICULTURAL EDUCATION. — The extension work of this department is devoted to the promotion of agriculture and practical arts relating to country life in the public schools of the State. This is done by means of conferences with school officials and school patrons, the promotion of agricultural clubs among the school children and giving lectures before granges, farmers' clubs, and other organizations interested in this line of endeavor. The work of the agricultural clubs is under the local management of the superintendent of schools or of some one suggested by him. Each town is expected to hold an exhibit of products. Exhibits covering rather extensive districts are incorporated with the various agricultural fairs in the State. In this way the promotion of elementary instruction in agriculture is carried on by the combined efforts of the public schools, of the patrons of the schools through their agricultural fairs, and of the Agricultural College.

The college aspect of the work is under the immediate direction of Associate Prof. O. A. Morton. His entire time is devoted to it. His services are at the disposal of the schools and school patrons in helping to promote the teaching of agriculture.

DEMONSTRATION FIELD PLOTS. — Aside from the work done by the Massachusetts Agricultural College Agricultural Improvement Association, little has been done toward placing demonstration plots in different sections of the State. This work is to be developed during the coming year, however.

LIBRARY EXTENSION WORK. — The college library has charge of this part of the Extension Service, which has to do with the circulation of agricultural literature throughout the State. This line of endeavor was instituted in 1910 by the sending out of four collections of books on agriculture and related subjects. The demand for these traveling libraries has been such that the work has grown to splendid proportions, there being now on hand a collection maintained, separate from the regular college library equipment, of nearly 600 books and pamphlets especially for this purpose. This book material is loaned out to the public libraries of the State upon request, and for such periods of time as may be regulated by supply and demand. Collections vary in size and character according to the nature of the need of the locality. From January to October, 1912, a total of 629 volumes were loaned to 37 libraries.

CO-OPERATION WITH EXISTING ORGANIZATIONS. — The aim of those in charge of the Extension Service has been, from the start, to co-operate with existing organizations so far as possible. During the past three years it has co-operated with the State Board of Agriculture, the State Board of Health, the State Dairy Bureau, the State Grange, the Boston Chamber of Commerce, the Springfield Board of Trade, the work of several of the various village improvement associations, the Tent Evangelistic Work in western Massachusetts, Federation of Churches of Massachusetts, State Board of Education, Free Public Library Commission, Massachusetts Civic League, State Board of Health, county work of Y. M. C. A., New England Home Economics Association, the Russell Sage Foundation, the Board of Home Missions, besides men's clubs in churches, women's clubs, schools and other agencies.

CO-OPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE. — Through the co-operation of the United States department it has been possible to place in Massachusetts a field agent whose duty it is to visit farms and consult with the owners, aiding them in questions of farm management, and to conduct farm management investigations.

DISTRICT FIELD AGENTS. — It is hoped that the college will soon be able to have in each county of the State a field agent whose duty it will be to visit farmers in the county, bringing to them the best advice the experts at the college can give.

During the coming year Mr. A. W. Doolittle, superintendent of the Faunce Demonstration farm, Sandwich, will serve the college on part time as field agent for Barnstable County.

Information by Correspondence. — Besides these things already mentioned thousands of helpful circulars and bulletins are printed and distributed, hundreds are helped through personal visits to farms, and still larger numbers through letters of inquiry which always receive the most careful attention from every department of the institution.

Pamphlets and bulletins are sent free to all who ask for them, and correspondence from any who desire such help as has been mentioned is gladly received. Address all communications to the Director of the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

Statistics of the Extension Service for 1912.

		People reached during 1912.
Enrollment in Short Courses.		
Ten Weeks' Winter Course,	131	
Poultry Course,	80	
Apple Packing School,	40	
Farmers' Week,	1,040	
Beekeepers' Course,	10	
Polish Farmers' Day,	57	
Conference for Rural Community Leaders,	184	
		1,482
Correspondence Courses.		
Present enrollment,	578	
Courses completed and work dropped during year,	175	
		753
Lectures.		
Number given,	591	
Approximate attendance,	27,469	27,469
Boys' and Girls' Clubs.		
Number of clubs,	127	
Number of members,	13,462	13,462
Massachusetts Agricultural College Agricultural Improvement Association.		
Members enrolled,	137	137
Dairy Improvement Associations.		
Members enrolled,	55	55
Extension Schools.		
Total membership in five schools,	500	500
Student Extension Work.		
Attendance each week at four evening schools,	80	80
Mailing List.		
Facts for Farmers,	1,553	
Short Courses,	3,764	
		5,317
Total,		49,366

GENERAL INFORMATION.

GENERAL INFORMATION.

A. FINANCIAL AND ADMINISTRATIVE.

STUDENT EXPENSES.

TUITION. — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $40 a year. The tuition charged persons not citizens of the United States is $120 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk stating that the applicant's father is a legal resident of Massachusetts.

DORMITORIES AND BOARD. — The college has dormitory accommodations for about 62 students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suits of three, — one study room and two bed rooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1.25 to $3 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present the price of board there is about $4 a week. Board is furnished at cost, the price being determined by adding 5 per cent. to the audited rate for the previous three months, and at the end of the period final settlement is made on the basis of actual cost.

EXPENSES.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts free; other citizens of the United States, $40 a year; foreigners, $120 a year.

	Low.	High.
Room in college dormitories or in private houses,	$39 00	$110 00
Board in college dining hall, $4 a week,	144 00	144 00
Laundry, 50 cents to 85 cents a week,	18 00	30 00
Military uniform, first year,	13 50	13 50
Laboratory fees,	2 00	20 00
Books, stationery and other miscellaneous,	23 50	32 50
	$240 00	$350 00

OTHER EXPENSES. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student furniture in dormitories either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $250 and $350 per year.

Initial Charges.

At the opening of the college year, before students are registered in their classes, the following charges are payable at the treasurer's office: —

	Freshmen.	Sophomores.	Juniors and Seniors.
Board (if at college dining hall) four weeks in advance,	$16 00	$16 00	$16 00
Subscription to "Signal" (college paper),[1] . .	1 50	1 50	1 50
Assessment for support of Social Union, . . .	1 50	1 50	1 50
Laboratory fees: —			
Chemistry, ...	5 00	-	-
Zoölogy, ...	-	2 00	-
For elective subjects, ...	-	-	1 00–10 00
Military uniform, ...	13 35	-	-
Room rent (if in college dormitory), ...	-	-	19 50–33 00
Student tax for support of athletics,[1] . . .	8 00	8 00	8 00
	$45 35	$29 00	$47 50–$70 00

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[1] While this is not essentially a college charge, the treasurer of the college acts as collector for the student activity, and all students are expected to make the payment as indicated. The subscription price of the "Signal" is fixed by the managers; the amount of athletic tax by vote of the student body.

Laboratory Fees.

The principles observed in establishing laboratory fees are the requirement that students pay for those materials actually used which cannot be supplied by the individual, and that the laboratory fees include a charge sufficient to guard against wanton waste and breakage.

The fees as indicated below will become effective in September, 1913.

Agronomy: —	Per Semester.
Course 3, ...	$1 50
Course 4, ...	0 50
Course 5, ...	1 00
Course 6, ...	1 00

	Per Semester.
Animal husbandry: —	
Courses 2 and 4, each,	$1 00
Course 7,	2 00
Botany: —	
Graduates,	4 00
Courses 2 and 3,	3 00
Course 4,	2 00
Course 5,	1 00
Courses 7, 9, 11, 13,	3 00
Chemistry: —	
Courses 1, 2, 7, 8, 13, 15,	3 00
Courses 3, 4, 5, 6,	4 00
Courses 9, 10, 11, 12, 14, 16,	5 00
Course 18,	No fee.
Entomology: —	
Graduates,	3 00
Entomology 3 and 4 each,	3 00
Landscape gardening: —	
Landscape gardening 1,	2 50
Landscape gardening 2,	2 50
Landscape gardening 3,	3 00
Landscape gardening 4,	3 00
Landscape gardening 6,	1 00
Landscape gardening 7,	3 00
Landscape gardening 8,	3 00
Drawing 1 and 2 each,	2 50
Pomology: —	
Pomology 3 and 4 each,	5 00
Poultry husbandry: —	
Course 3,	1 50
Course 4,	2 00
Zoölogy: —	
Elementary 1,	2 00
Invertebrate 3,	4 00
Vertebrate,	4 00

STUDENT AID.

SELF HELP. — A number of students find opportunities for earning money without depending upon the college to furnish them with work, and many are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should undertake work that interferes with his studies, and students should remember that, owing to the large number of applications for employment, no one man can receive a large amount of work through the college.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and thirty or more students are employed at the dining hall. Applications for student labor should be made directly to the president. Applicants are required to present a certificate, signed by parent or guardian and by one of the selectmen or aldermen of the town or city in which they reside, showing that the applicant needs the assistance. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

SPECIAL NOTICE TO NEEDY STUDENTS. — In the last year or two the demand for paid labor on the part of new students has far exceeded the amount of employment that the college can offer. The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

STUDENT ACCOUNTS.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each semester. This rule is strictly adhered to, and no student will be allowed to register in his class until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each semester at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the semester he is more than one week in arrears in his payment for board.

All money due for student labor shall be applied on account toward any bills that a student may owe to the institution.

STUDENT RELATIONS.

The customary high standard of college men in honor, manliness, self-respect and consideration for the rights of others constitutes the standards of student deportment.

Any student known to be guilty of dishonest conduct or practice must be reported by the instructor to the president for discipline.

The privileges of the college may be withdrawn from any student at any time, if such action is deemed advisable.

It should be understood that the college, acting through its president or any administrative officer designated by him, distinctly reserves the right not only to suspend or dismiss students, but also to name conditions under which students may remain in the institution. For example, if a student is not doing creditable work he may not only be disciplined but he may also be required to meet certain prescribed conditions in respect to his studies, even though under the foregoing rules his status as a student be not affected. The same provision applies equally to the matter of absences ("cuts"). According to the rules a student is allowed a certain percentage of absences from class and other exercises. This permission, which implies a privilege and not a right, may be withdrawn at any time for any cause.

Similarly, also, it applies to participation in student activities. Though this will ordinarily be governed by the rules as already laid down, yet, if in the judgment of the college authorities a student is neglecting his work on account of these activities the privilege of participating in them may be withdrawn for such time as is considered necessary. Moreover, it may be withdrawn as a punishment for misconduct. Prospective students or their parents may, upon application, obtain a copy of the faculty rules governing student relations to the college.

B. COLLEGE ACTIVITIES.

General Exercises.

Chapel exercises are as a rule held four mornings each week. On Wednesday, instead of chapel an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the president is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

Student Activities.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established about four years ago. All students become members of the Union by paying a small fee. The Union is designed to become the center of student interests. In North College it has a trophy room and a large lounging room for music, reading and study. In the basement of this building there is also a game room for pool and billiards. In the fall and winter months the Union gives a series of entertainments, free to the students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of under-graduate conduct, and represents before the faculty the interests of the student body.

The M. A. C. Christian Association is active both socially and religiously. Under its direction voluntary Bible classes are conducted during the winter months. A Catholic Club has also been organized.

The musical organizations include an orchestra, a mandolin club and a glee club. These furnish music for college meetings, and occasionally give concerts at the college and at other places. A military band is maintained as part of the cadet corps.

A Dramatic Club has been organized, and each year presents a play.

The Public Speaking Council represents the students' interest in debate and oratory.

The Athletic Association represents in the college the interests of football, baseball, track, hockey and tennis.

A Rifle Club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

The college publications are the "Signal," published weekly by the student body, and the "Index," published annually by the members of the junior class. As a part of the work in journalism, students supply The Bay State Ruralist, a special page in the "Springfield Union."

The Stockbridge Club is an organization of students especially interested in practical agriculture, horticulture and floriculture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

Scientific clubs also exist in the departments of French, entomology and landscape gardening.

C. ACADEMIC AND DEPARTMENTAL.

Degrees.

Those who complete a four-year course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10. Credit may sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-years course of study, and present a satisfactory thesis, will be granted the degree of doctor of philisophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest fifth of the senior class who have attained an average grade of at least 85 per cent. during their college course.

Prizes.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1912 are: —

Agriculture. — The Grinnell prizes (first, second and third), given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture. They are $25, $15 and $10.

Animal Husbandry. — The F. Lothrup Ames' Prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, beginning 1912, to be given to the three students standing highest in the work of advanced live-stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago.

BOTANY. — The Hills prizes (amounting to $35), given by Henry F. Hills of Amherst, will be awarded to members of the senior class as follows: for the best herbarium, $15; for the best collection of Massachusetts trees and shrubs, $10; for the best collection of Massachusetts woods, $10. No collection deemed unworthy of a prize will be considered. In 1913, a prize of $5 is offered to that member of the sophomore class who presents the best herbarium of native flowering plants.

GENERAL IMPROVEMENT. — The Western Alumni Association prize ($25) is given to that member of the sophomore class who, during the first two years in college, has shown the greatest improvement in scholarship, character and example.

PUBLIC SPEAKING. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declarations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and $20 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students. Interclass debates, with prizes, are also held annually.

MILITARY DIPLOMAS.

Military diplomas are given to those men receiving the degree of bachelor of science who by their work in the department of military science have shown themselves worthy of distinction. These diplomas recommend those receiving them for commissions in the United States army or the militia of the several States.

EQUIPMENT.

AGRONOMY. — The work in agronomy is carried on by means of lectures, laboratory work and field work. The laboratories are in the north wing of South College. The seed laboratory is equipped with samples of the different grains and seeds of economic importance in field culture, and with apparatus for the study and testing of these seeds, including microscopes and the apparatus necessary for viability and purity tests. The soil laboratory is well equipped with apparatus for the study of the physical properties of soils, including an electric centrifuge; an electric resistance thermometer for determining soil and other temperatures; evaporimeters and drying ovens; and good balances. For the work in drainage there is available a surveyor's transit, a wye level, drainage levels, rods, steel tapes, surveyor's pins, and a set of drainage tools. The college farm may also be considered a part of the agronomy laboratory.

ANIMAL HUSBANDRY. — The most important part of the equipment for laboratory work in animal husbandry is the new judging pavilion, which will be completed by Jan. 1, 1911. This will give new opportunities for practice work in management of live stock, together with demonstrations in judging. Another very essential part of the equipment for this department is the live stock of the college farm, which includes pure bred and grade Ayrshire, Guernsey, Holstein and Jersey cattle, French coach and Percheron horses, and Berkshire swine. A set of plaster-of-paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different food stuffs available for the use of the New England farmer, are included in the equipment for this work.

BOTANY. — The department of botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for sophomore and junior work, and one for senior work; and three rooms specially fitted for graduate students. The experiment station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with all necessary conveniences. The basement contains a bacteriological laboratory, a seed and soil room; and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe, and other tools and appliances. In the senior laboratory is a room designed especially for physiological work; this laboratory is well supplied also with apparatus for the study of simple phenomena in plant physiology, such as respiration, metabolism, transpiration, heliotropism, etc. The herbarium contains 15,000 species of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and about 12,000 sheets of fungi. The laboratory is equipped with 90 modern compound microscopes and a number of dissecting microscopes, microtomes and a large series of charts. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experiment work and for housing material often needed in the laboratory.

CHEMISTRY. — The chemical department of the college now occupies the entire building previously known as the "old chapel." The basement is used for the storage of apparatus and chemicals. The first floor contains large laboratories devoted to qualitative and quantitative analysis and organic and physiological chemistry. The second floor is occupied by the general lecture room, by offices for the several members of the staff, by laboratories for physical chemistry and for beginners in quantitative analysis. The third floor has recently been fitted for work in general chemistry, and has desk room and hoods sufficient to accommodate 66 students at one time. Each place is supplied with reagents and apparatus for independent work. This floor is also occupied by a lecture room that will seat 100 students.

The entire laboratory is well equipped with the necessary apparatus and chemicals for all students who desire to perfect themselves as expert chemists, or who wish to study chemistry as a supplement to some other line of practical or scientific work. The equipment includes a valuable and growing collection of specimens and samples of minerals, soils, raw and manufactured fertilizers, food, milk products, fibers, various other vegetable and animal products and artificial preparations of mineral and organic compounds; and also a series of preparations for illustrating the various stages of different manufactures from raw material to finished product.

DAIRYING. — Two large, well-drained, cement-floored rooms in the South College are used for dairy work. These are equipped with a milk heater, separators, coolers and aërators, a pasteurizer, ripening vats, churns, butter workers, a mechanical can washer, a sterilizer, and other small apparatus necessary to a well-equipped dairy or butter factory. A third room is equipped with hand and power Babcock milk-testing machines and other apparatus used for milk and butter testing. These rooms have individual lockers for students. The new sanitary dairy and stable give an opportunity for practical laboratory work in the production and handling of certified milk.

DINING HALL. — Draper Hall, a brick colonial building, equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college.

DRAWING. — Two rooms on the second floor of Wilder Hall are occupied by the classes in drawing. They are equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details, and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

ENTOMOLOGY. — GENERAL ENTOMOLOGICAL LABORATORIES. — The equipment for work in entomology is perhaps unexcelled in this country. In the new fireproof entomogical and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped. It will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump and methods of repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room, provided with chemical desks and apparatus, methods for the determination of the impurities and adulterations of insecticides are taught. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

Entomology. — Beekeeping. — For this work the main office, museum and lecture rooms are in the entomological building. There is also an apiary covering approximately two acres which will consist of about fifty colonies of bees in various types of hives and maintained for the several practical and experimental purposes. The apiary also includes a collection of nectar-yielding plants representative of the native flora as well as of the more important nectar sources from other localities. Especial opportunity is therefore given for a study of this fundamental problem of forage. Upon the apiary site is an eight-room building (the first in the world erected exclusively for teaching beekeeping) modeled to meet both the requirements of teaching and of a practical apiary. This building contains a boiler room, capacious wintering cellar, wax extraction room, general carpenter and work shop, laboratory, office, honey extraction room and stock room. The beekeeping equipment also includes an unexcelled collection of apicultural implements, natural history specimens and other curiosities. Practically every device used in American apiculture is available, it being the aim of the department to procure new inventions and implements as fast as they appear for the purpose of study and comparison. Available to the students is a private library of apicultural literature consisting of upwards of 700 volumes and papers, possibly the most complete collection in the country. This entire equipment is acknowledged unique in model and in completeness for the United States and for the world.

Farm Administration. — The college farm of 190 acres is under the supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The work in this department includes the production of the common field crops, and the care and raising of the different classes of live stock mentioned under animal husbandry. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied.

Floriculture. — The department of floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a department of floriculture better equipped than this. The legislative appropriation of 1908 has made possible the erection of a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

FORESTRY. — The department of forestry has an unusually complete equipment of the various instruments used in forest mensuration, forest mapping and engineering, timber estimating, log scaling, board measuring, etc.; a large assortment of boards illustrative of the various commercial woods found in the lumber markets. The State Forest Nursery, comprising 6 acres of land and containing, approximately, 5,000,000 trees, transplants and seedlings is located on the college farm. Extensive forests containing every variety of tree common to New England are within walking distance of the college. The college campus affords an arboretum containing an exceptionally large number of trees not native to New England. The library contains complete sets of government bulletins, circulars, State reports and all the best books on forestry subjects.

GEOLOGY. — A large, well-lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections, and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has six large cases for exhibition purposes.

The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts, and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

HEATING, LIGHTING AND POWER. — The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop.

LANDSCAPE GARDENING. — The work in landscape gardening is developed in a strong technical four-year course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape gardening, arboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

LIBRARY. — The library — stack room, reading room and office — occupies the entire lower floor of the library-chapel building. It contains nearly 34,000 volumes and a large number of pamphlets, hitherto inaccessible, but which are being put into good working order as fast as possible. Works of a scientific character predominate, but economics, literature and history are well represented and are receiving due attention. The reading room provides a variety of periodical literature, both technical and popular, encyclopedias and general reference books, and a select collection of works for general reading.

The library is now being reclassified and recatalogued, to make the splendid collection of material here gathered together readily accessible and of the greatest working value. Every effort is being made toward developing the library into a vital intellectual center of college life, of equal value to every student, teacher and teaching department. In consequence, only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced.

Lectures are given to regular short course students to enable them to make the best use of the library. Emphasis is laid upon the proper use of the card catalogue, periodical indexes, bibliographies and guides; also, in general, assigned and class-room work, and essay and debate work.

The library hours are from 7.45 A.M. to 9 P.M. every week day, and from 9 A.M. to 2 P.M. on Sundays, in term time. Shorter hours prevail during vacations.

MARKET GARDENING. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and a laboratory particularly equipped for floriculture and market gardening. A good library of works on vegetable gardening is available.

MATHEMATICS AND CIVIL ENGINEERING. — *Surveying.* — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a queen plane table, 3 wye levels, 2 dumpy levels, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

Military Science. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60 by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

Physical Education. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The room used for exercise and recreation is equipped with modern developing apparatus and two hand-ball courts, and is large enough for basket ball. The apparatus can quickly be removed to clear the floor. An out-door board track enables students to secure track practice through the winter. Steel lockers and bathrooms have been installed in North and South colleges, and the gymnasium has been fitted with a bathroom. The gymnasium is open from 9 a.m. to 10 p.m., and exercise may be taken at such hours as do not conflict with military drill or physical education classes. The regulation costume for class exercise consists of a white track suit and white, rubber-sole shoes.

Physics. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

Pomology. — The department of pomology has 10 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. Of particular interest is the large collection of these fruits on the various dwarf stocks, showing many types of training. The recent revival of interest in dwarf fruits makes these dwarf orchards of especial value to students. There is also a commercial vineyard and a smaller one; in these are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also extensive nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collection of more than 100 wax models of apples and plums in natural colors, which are particularly valuable in identifying varieties of these fruits unknown to the student. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1909–10, for instance, apples for class use were received from British Columbia, Ontario, Quebec, Nova Scotia, Iowa, Wisconsin, Michigan, Connecticut, New York, Oklahoma, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrus fruit from Florida and Texas.

POULTRY HUSBANDRY. — The poultry plant consists of about 9 acres of land sloping gently to the west. The soil is a fine, rich, sandy loam, well drained. At present the buildings consist of an incubator cellar, 32 by 34 feet, with a capacity of 4,000 eggs, over which is a demonstration building; a pipe brood house (open-pipe system), 14 by 72 feet, which will accommodate 1,200 chickens; a long laying house, 14 by 180 feet, which accommodates 500 layers and furnishes facilities for student work in pen management; a laboratory, 14 by 80 feet, for killing, picking, dressing, crate fattening, cramming, etc.; a storage building, 28 by 42 feet, for experimental incubation, poultry carpentry, poultry mechanics and storage; an experimental breeding house, 18 by 60 feet; the 6 old experiment station buildings, each 12 by 18 feet, to be used as breeding houses, and 11 colony brooder houses. Instruction in this department is given in the form of lectures, demonstrations and practical work. The practical work consists of poultry, carpentry, caponizing, killing, picking, dressing, packing and selling poultry; pen management and fattening; running incubators and brooders, etc. At present the stock consists of 20 leading varieties of poultry. The aim of the department is to keep good specimens of all the most popular varieties of chicken, ducks and geese, so that a thorough course in poultry judging may be given, and that visitors may find the inspection of our stock an education in itself.

PUBLIC SPEAKING. — In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sophomores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests furnish a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Intercollege contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the College Debating Club.

VETERINARY SCIENCE AND BACTERIOLOGY. — The department of veterinary science and bacteriology occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There are a lecture hall, a museum, a demonstration room, a photographing room and a work shop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in bacteriology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

ZOÖLOGY. — The college offers increased facilities for the study of zoölogy. In the new building for entomology, zoölogy and geology are spacious laboratories for both undergraduate and graduate work. On the first floor is a large sophomore laboratory, 27 by 100 feet, with a present seating capacity of 100 persons. Adjoining this is a smaller room, 20 by 27 feet, for junior and senior courses. On the second floor is a laboratory, 20 by 32 feet, for advanced work. All laboratories are equipped with gas. The equipment consists of 80 compound microscopes and accessories, 70 dissecting microscopes, microtomes and accessories, paraffine baths, incubator, dissecting instruments, glassware and other necessary apparatus.

The large amphitheater lecture hall is used jointly by the departments of entomology and zoölogy-geology. It is equipped with charts and models. The zoölogical museum is drawn upon at all times for illustrative material. The zoölogical museum is 27 by 48 feet. The main room is on the first floor of the building. Above this, on a level with the second floor, is a large gallery. On the main floor are 8 large wall cases and 5 large floor cases for exhibition purposes. The gallery has 1 one large wall case and 2 floor cases with space for 10 additional cases. The zoölogical collection consists of nearly 12,000 specimens. All the chief phyla are represented. Adjoining the museum is a preparator's room for the curator. The museum is open to the public from 1 to 5 P.M. on Saturdays, and on other week days from 3 to 6 P.M. The curator is Associate Professor Gordon.

PRIZES AND AWARDS, 1912.

GRINNELL PRIZES. — The Grinnell prizes, given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture, were awarded as follows: —

First prize, $25, to Benjamin Gilbert Southwick.

Second prize, $15, to Francis Spink Madison.

Third prize, $10, to Eric Nichols Boland.

BOTANICAL PRIZES. — The Hills prizes, given by Henry F. Hills of Amherst, were awarded to members of the senior class as follows: —

A. — For the best herbarium, $15, to Ray Ethan Torrey.

B. — For the best collection of Massachusetts trees and shrubs, $10, to Ray Ethan Torrey.

C. — For the best collection of Massachusetts woods, $10, to Ray Ethan Torrey.

Special sophomore prize for the best herbarium, $5, to Ernest Elwood Stanford.

Honorary mention made of Raymond Edward Nute.

General Improvement. — The Western Alumni Association prize, given to that member of the sophomore class who during his first two years in college has shown the greatest improvement in scholarship, character and example, was awarded as follows: —

Twenty-five dollars to Roland Alfred Payne.

Public Speaking. — The Burnham prizes, given to the students delivering the best and second best declarations, were awarded as follows: —

First prize, $15, to Leroy Everett Haskins.

Second prize, $10, to Isaac Barney Simon.

The Flint prizes, given to the students delivering the best and second best orations, were awarded as follows: —

First prize, a gold medal and $20, to Dau Yang Lin.

Second prize, a gold medal and $15, to Woon Young Chum.

Debating. — The prizes in the annual debate were awarded as follows: —

Fifteen dollars and a gold medal, to Theodore Joseph Moreau.

Fifteen dollars and a gold medal, to Benjamin Franklin Hubert.

Fifteen dollars and a gold medal, to Thomas Hemenway.

The prizes in the interclass debate were awarded as follows: —

To the team representing the Class of 1912, consisting of Theodore Joseph Moreau, Benjamin Franklin Hubert, Thomas Hemenway.

Each member of the above team was awarded a silver cup.

Military Honors. — The following-named cadet officers have been reported to the Adjutant-General of the United States army and to the Adjutant-General of the Commonwealth of Massachusetts, being efficient in military science and tactics and graduating therein with highest honors: —

Cadet Col. Marshall Cotting Pratt.

Cadet Maj. Eric Nichols Boland.

Cadet Capt. Benjamin Gilbert Southwick.

Cadet Capt. Francis Spink Madison.

Cadet Capt. Thomas Hemenway.

Secretaries of Alumni Associations and Classes.

Alumni Secretaries' Association of the Massachusetts Agricultural College.
Secretary: Ralph J. Watts, 1907, Amherst, Mass.

Association Alumni of the Massachusetts Agricultural College.
Secretary: Sidney B. Haskell, 1904, Amherst, Mass.

Local Alumni Association of the Massachusetts Agricultural College.
Secretary: Sidney B. Haskell, 1904, Amherst, Mass.

Alumni Club of Massachusetts.
Clerk: H. Linwood White, 1909, 136 State House, Boston, Mass.

Connecticut Valley Association of the Massachusetts Agricultural College.
Secretary: Charles L. Brown, 1894, 870 State Street, Springfield, Mass.

Massachusetts Agricultural College Club of New York.
Secretary: John Ashburton Cutter, 1882, 262 West 77th Street, New York, N. Y.

Massachusetts Agricultural College Club of Washington, D. C.
Secretary: Clarence H. Griffin, 1904, 1864 Park Road, Washington, D. C.

Western Alumni Association of the Massachusetts Agricultural College.
Secretary: Charles A. Tirrell, 1906, 4012 Perry Street, Chicago, Ill.

Massachusetts Agricultural College Pacific Coast Alumni Association.
Secretary: Thomas F. Hunt, 1905, Berkeley, Cal.

Class Secretaries.

Class of	SECRETARY.	Secretary's Address.
1871	E. E. Thompson,	5 Jacques Avenue, Worcester, Mass.
1872	F. E. Kimball,	8 John Street, Worcester, Mass.
1873	C. Wellington,	Amherst, Mass.
1874	D. G. Hitchcock,	Warren, Mass.
1875	M. Bunker,	Newton, Mass.
1876	C. Fred Deuel,	Amherst, Mass.
1877	Atherton Clark,	Newton, Mass.
1878	C. O. Lovell,	5 Bromfield Street, Boston, Mass.
1879	R. W. Swan,	41 Pleasant Street, Worcester, Mass.
1880	Alvan Fowler,	413 Post Office Building, Philadelphia, Pa.
1881	J. L. Hills,	59 North Prospect Street, Burlington, Vt.
1882	G. D. Howe,	25 Winter Street, Bangor, Me.
1883	J. B. Lindsey,	Amherst, Mass.
1884	– –	– –
1885	E. W. Allen,	1923 Biltmore Street, Washington, D. C.
1886	Dr. Winfield Ayres,	616 Madison Avenue, New York City.
1887	F. H. Fowler,	Shirley, Mass.
1888	H. C. Bliss,	14 Mechanic Street, Attleborough, Mass.
1889	C. S. Crocker,	1003 South 25th Street, Philadelphia, Pa.
1890	David Barry,	398 Walnut Street, Newtonville, Mass.
1891	H. T. Shores,	177 Elm Street, Northampton, Mass.
1892	H. M. Thomson,	Amherst, Mass.
1893	F. A. Smith,	Turner Hill, Ipswich, Mass.
1894	S. F. Howard,	Amherst, Mass.
1895	E. A. White,	Amherst, Mass.
1896	A. S. Kinney,	South Hadley, Mass.
1897	C. A. Peters,	Amherst, Mass.
1898	– –	– –
1899	D. A. Beaman,	Rio Piedras, Porto Rico.
1900	E. K. Atkins,	15 Hubbard Avenue, Northampton, Mass.
1901	J. H. Chickering,	Dover, Mass.
1902	H. L. Knight,	1420 Buchanan Street, Washington, D. C.
1903	G. D. Jones,	North Amherst, Mass.
1904	P. F. Staples,	North Grafton, Mass.
1905	A. D. Taylor,	1101 Tremont Building, Boston, Mass.
1906	Richard Wellington,	Geneva, N. Y.
1907	Clinton King,	6 Beacon Street, Boston, Mass.
1908	J. A. Hyslop,	860 North Mulberry Street, Hagerstown, Md.
1909	O. B. Briggs,	1015 Fidelity Building, Baltimore, Md.
1910	F. L. Thomas,	Amherst, Mass.
1911	L. M. Johnson,	Newtown, Conn.
1912	F. S. Madison,	East Greenwich, R. I.

DEGREES CONFERRED AND ROLL OF STUDENTS.

DEGREES CONFERRED — 1912.

DOCTOR OF PHILOSOPHY.

Bartlett, Oscar Christopher, Westhampton. Massachusetts Agricultural College, B.Sc., 1909.

MASTER OF SCIENCE.

McLaine, Leonard Septimus, New York, N. Y. Massachusetts Agricultural College, B.Sc., 1910.

BACHELOR OF SCIENCE (B.SC.).

Ackerman, Arthur John,	Worcester.
Baker, Horace Mitchell,	Selbyville, Del.
Beals, Carlos Loring,	Sunderland.
Beers, Rowland Trowbridge,	Billerica.
Bent, William Richard,	Marlborough.
Bodfish, Edward Hill,	West Barnstable.
Boland, Eric Nichols,	South Boston.
Brett, Alden Chase,	North Abington.
Brown, Merle Raymond,	Greenwich Village.
Burnham, Arthur James,	Holyoke.
Burr, Frederick Huntington,	Worthington.
Carpenter, Jesse, Jr.,	Attleborough.
Castle, Fred Arlo,	Roseburg, Ore.
Clapp, Raymond Kingsley,	Westhampton.
Curran, Daniel Joseph,	Marlborough.
Deming, Winfred Griswold,	Wethersfield, Conn.
Dodge, Albert Wesley,	South Hamilton.
Fagerstrom, Leon Emanuel,	Worcester.
Fisherdick, Warren Francis,	Amherst.
Fitts, Frank Orus,	North Amherst.
Fitzgerald, John Joseph,	Holyoke.
Fowler, George Scott,	Wayland.
Gallagher, James Andrew,	North Wilmington.
Gaskill, Lewis Warren,	Hopedale.
Gelinas, Louis Edmond,	North Adams.
Gibbs, Robert Morey,	Chester.
Gibson, Lester Earl,	Melrose.
Gray, Frank Leonard,	East Boston.
Hall, Henry Bass,	Northampton.
Hall, Horace Whitney,	Newton Centre.
Hallowell, Royal Norton,	Jamaica Plain.
Hamblin, Stephen Francis,	Marstons Mills.
Harlow, Joseph Alvin,	Turners Falls.
Heald, Jay Morrill,	Watertown.
Hemenway, Thomas,	Nashua, N. H.
Hickey, Francis Benedict,	Brockton.
Hills, Frank Burrows,	Bernardston.
Holland, Henry Lucius,	Amherst.
Hubert, Benjamin Franklin,	White Plains, Ga.
Kingsbury, Arthur French,	Medfield.
Lamson, Robert Ward,	Amherst.
Lin, Dau Yang,	Shanghai, China.
Lodge, Charles Albert,	Manchester.
Madison, Francis Spink,	East Greenwich, R. I

Martin, James Francis,	Amherst.
McGarr, Thomas Anthony,	Worcester.
Merkle, George Edward,	Amherst.
Merrill, Fred Sawyer,	Danvers.
Moreau, Theodore Joseph,	Turners Falls.
Mueller, Alfred Frederick,	Jamaica Plain.
Noyes, Harry Alfred,	Marlborough.
O'Flynn, George Bernhard,	Worcester.
Parker, Ralph Robinson,	Malden.
Pearson, Charles Cornish,	Arlington.
Peckham, Curtis,	New Bedford.
Philbrick, William Edwin,	Taunton.
Pierpont, John Edwards,	Williamsburg.
Pratt, Marshall Cotting,	Holderness, N. H.
Puffer, Stephen Perry,	North Amherst.
Raymond, Arthur Nathaniel,	Leominster.
Reed, Robert Edward,	Abington.
Robinson, Earle Johnson,	Hingham.
Rockwood, Lawrence Peck,	Waterbury, Conn.
Sanctuary, William Crocker,	Amherst.
Sellew, Lewis Raymond,	Natick.
Shaw, Ezra Ingram,	Amherst.
Southwick, Benjamin Gilbert,	Buckland.
Stack, Herbert James,	Conway.
Terry, Leon,	Springfield.
Torrey, Ray Ethan,	North Leverett.
Tower, Daniel Gordon,	Roxbury.
Tupper, George Wilbur,	Roxbury.
Turner, Howard Archibald,	Dorchester.
Wales, Robert Webster,	North Abington.
Warner, Roger Andrew,	Sunderland.
Weaver, William Jack,	Alandar.
Whitney, Charles Everett,	Wakefield.
Wilbur, Emory Sherman,	East Wareham.
Wilde, Earle Irving,	Taunton.
Williams, Edward Roger,	Concord.
Williams, Silas,	Fall River.
Wood, Howard Holmes,	Shelburne Falls.
Young, Edwin Burnham,	Dorchester.

ROLL OF STUDENTS.

SENIOR CLASS.

Adams, Winford Frederick,[1]	East. Leverett,	Theta Chi House.
Allen, Harry Willis,	West Pelham,	West Pelham.
Anderson, Oscar Gustaf,	East Pepperell,	Entomological Building.
Angier, Harris William,	Westborough,	South College Tower.
Baird, Harry Albert,[1]	Somerville,	4 South College.
Baker, Dean Foster,	Fairhaven,	15 North College.
Barber, George Ware,[1]	Hyde Park,	13 North College.
Bevan, Laurence Algur,[1]	Newtonville,	15 North College.
Birdsall, Webster Jennings,[1]	Otego, N.Y.,	Kappa Sigma House.
Borden, Ralph James,	Fall River,	7 North College.
Brewer, Charlesworth Herbert,	Mt. Vernon, N.Y.,	C. S. C. House.
Brown, Herbert Augustine,	Saxonville,	Brooks Farm.
Bullard, Alvan Henry,	South Framingham,	3 North College.
Burby, Lawrence Walter,	Chicopee Falls,	Theta Chi House.
Bursley, Harold Barrows,	Peabody,	5 North College.
Carver, John Stuart,	Roslindale,	C. S. C. House.
Clark, Norman Russell,	Millbury,	Theta Chi House.
Cobb, Joseph Boyd,[1]	Chicopee Falls,	5 North College.
Cole, Arlin Tower,	West Chesterfield,	2 North College.
Cole, Flora Atwood,	Newton,	Draper Hall.
Coleman, Isaac,[1]	Amherst,	12 North College.
Cooper, Everett Hanson,[1]	Greenwood,	11 North College.
Cory, Harold,	Rutherford, N. J.,	15 Beston Street.
Covill, Joseph Warren,[1]	Roxbury,	7 South College.
Cristman, Clyde Edward,[1]	Dalton,	2 North College.
Culley, Frank Hamilton,	Marshalltown, Ia.,	77 Pleasant Street.
Curtis, Harold William,[1]	Belchertown,	Entomology Building.
Daniel, Edward Stephen Coen,	Osterville,	7 South College.
Dayton, James Wilson,	Georgetown, Conn.,	4 North College.
Dooley, Thomas Patrick,	South Boston,	6 North College.
Drury, Lewis Floyd,	Rutland,	120 Pleasant Street.
Edminster, Albert Franklin,	Brooklyn, N. Y.,	5 South College.
Eisenhaure, John Louis,[1]	North Reading,	3 North College.
Ellis, Benjamin Ward,	Plymouth,	Kappa Sigma House.
Ells, Gordon Waterman,	Haverhill,	5 South College.
Fay, Robert Sedgwick,	Monson,	84 Pleasant Street.
Forbush, Wallace Clifford,	Rutland,	79 Pleasant Street.
French, James Dudley,	Hyde Park,	8 South College.
Gaskill, Ralph Hicks,	Amherst,	15 Hallock Street.
Gore, Harold Martin,	Wollaston,	11 South College.
Greenleaf, George Freeman,	Brockton,	21 Fearing Street.
Griggs, Frederick David,	Chicopee Falls,	18 South College.
Harris, Burton Adams,	Wethersfield, Conn.,	11 North College.
Hasey, Willard Harrison,[1]	Campello,	C. S. C. House.
Hatch, Herbert Tilden,	Atlantic,	East Experiment Station.
Headle, Herbert Wallace,	Bolton,	North College.
Headle, Marshall,	Bolton,	French Hall.
Holden, James Loomis,	Palmer,	3 North College.
Howe, Glover Elbridge,	Marlborough,	11 South College.

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[1] Work incomplete.

Howe, Ralph Wesley,	East Dover, Vt.,	Wilder Hall.
Huntington, Samuel Percy,	Lynn,	12 South College.
Hutchings, Herbert Colby,[1]	South Amherst,	9 North College.
Hyland, Harold Wilson,[1]	Weymouth,	Old Insectary.
Jones, Harold Frederic,	Campello,	West Experiment Station.
Jordan, Simon Miller,[1]	Rutherford, N. J.,	9 South College.
Kelley, Albert Joseph,	Roxbury,	1 North College.
Kelley, Bernard Jenkins,	Harwichport,	Brooks Farm.
Kenney, Frederick Alfred,[1]	Charlestown,	South College Tower.
Lesure, John Warren Thomas,	Fitchburg,	Flint Laboratory.
Little, Willard Stone,[1]	Newburyport,	6 South College.
Lowry, Quincy Shaw,[1]	Canton,	6 South College.
Lundgren, Arthur Robert,[1]	Orange,	Theta Chi House.
Lyon, Harold,	Somerville,	13 Phillips Street.
Macone, Joseph Augustine,	Concord,	4 South College.
Mallett, George Alfred,	Bridgeport, Conn.,	9 North College.
Matz, Julius,[1]	Lynn,	112 Pleasant Street.
Mayer, John Lawrence,	South Boston,	1 North College.
McDougall, Allister Francis,	Westford,	18 South College.
Moir, William Stuart,	Boston,	Theta Chi House.
Murray, Joseph Wilbur,	Holyoke,	Kappa Sigma House.
Neal, Ralph Thomas,	Mattapan,	Old Insectary.
Nichols, Norman Joseph,	Everett,	Physics Building.
O'Brien, James Leo,	Wayland,	10 South College.
Packard, Clyde Monroe,	Springfield,	84 Pleasant Street.
Pease, Lester Newton,	Meriden, Conn.,	17 South College.
Pillsbury, Joseph James,[1]	West Bridgewater,	8 South Prospect St.
Post, George Atwell,[1]	Richmond Hill, N. Y.,	Theta Chi House.
Roehrs, Herman Theodore,	New York, N. Y.,	Kappa Sigma House.
Rosebrooks, Walter Edwin,[1]	Essex,	14 North College.
Samson, Stuart Dodds,	Grand Isle, Vt.,	12 South College.
Selden, John Lincoln,	Northampton,	21 Fearing Street.
Serex, Paul, Jr.,	Jamaica Plain,	14 North College.
Sheehan, Dennis Anthony,[1]	South Lincoln,	1 North College.
Shute, Carl August,[1]	Quincy, Ill.,	14 South College.
Streeter, Charles Marsh,	Brimfield,	79 Pleasant Street.
Thayer, Clark Leonard,	Smith's,	8 North College.
Tucker, Waldo Guy,	Lynn,	Physics Building.
Van Zwaluwenburg, Reyer Herman,	Rutherford, N. J.,	17 South College.
Walker, Charles Dexter,	Greenwich Village,	14 South College.
Whitney, Francis Wellington,[1]	Wellesley,	4 North College.
Zabriskie, George, 2d,[1]	New York, N. Y.,	8 South College.

JUNIOR CLASS.

Abbott, Leslie Elmer,	Sandwich,	10 North College.
Allen, Carl Murdough,	Holyoke,	87 Pleasant Street.
Anderson, Leslie Oscar,[1]	Concord,	101 Pleasant Street.
Baker, Warren Sears,	Wollaston,	8 South College.
Black, Harold Cotting,[1]	Falmouth,	Kappa Sigma House.
Blake, Ralph Cedric,[1]	Wollaston,	15 Hallock Street.
Bokelund, Chester Story,[1]	Worcester,	10 South College.
Bradley, John Watling,[1]	Groton,	88 Pleasant Street.
Bragg, Ralph Stanley,	Milford,	Care of Professor White.
Brewer, Harold William,[1]	Mount Vernon, N.Y.,	C. S. C. House.
Brooks, Arthur Winslow,	Enfield,	79 Pleasant Street.
Brown, Harry Dunlap,[1]	Lowell,	Kappa Sigma House.
Calvert, Melville Bradford,	New London, Conn.,	58 Pleasant Street.
Campbell, Malcolm David,	Still River,	Poultry Building.
Christie, Edward Wheeler,	North Adams,	P. O. Box 152.
Churchill, George Clarence,	Worcester,	58 Pleasant Street.
Clark, Ernest Samuel, Jr.,	Tolland,	82 Pleasant Street.

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[1] Work incomplete.

Clay, Harold Johnson,	North Cambridge,	21 Fearing Street.
Clegg, Frank Jackson,[1]	Fall River,	2 South College.
Coe, Alfred Lynn,	Fayetteville, N. Y.,	79 Pleasant Street.
Cole, Herbert Elmer,[1]	Manchaug,	Plant House.
Coleman, David Augustus,	South Framingham,	108 Pleasant Street.
Davies, Lloyd Garrison,	Peabody,	15 South College.
Davis, Ralph Edward,[1]	Southbury, Conn.,	77 Pleasant Street.
Davis, William Ashmun,	Northfield,	79 Pleasant Street.
Dearing, Newton Howard,[1]	Brookline,	7 Nutting Avenue.
Demond, Robert Norton,	North Adams,	16 South College.
Dexter, Evans King,[1]	Mattapoisett,	Theta Chi House.
Dunbar, Erving Walker,	Weymouth,	116 Pleasant Street.
Edgerton, Almon Morley,[1]	West Springfield,	13 South College.
Edwards, Edward Clinton,[1]	Salem,	16 South College.
Eldridge, Harold Lockwood,[1]	Wareham,	88 Pleasant Street.
Foster, Stuart Brooks,[1]	West Somerville,	Kappa Sigma House.
Freeborn, Stanley Barron,	Ware,	116 Pleasant Street.
Freedman, Samuel Leavitt,	Roxbury,	101 Pleasant Street.
Frye, Carl Raymond,	South Hadley Falls,	116 Pleasant Street.
Fuller, George,	Deerfield,	86 Pleasant Street.
Griffin, William Gerald,	South Hadley Falls,	South Hadley Falls.
Hadfield, Harold Frederick,	North Adams,	East Pleasant Street.
Handy, Ralph Ellis,[1]	Cataumet,	10 North College.
Harris, Rodney Wells,	Wethersfield, Conn.,	77 Pleasant Street.
Hazen, Edward Leonard,[1]	Springfield,	Care of E. H. Forristall.
Hebard, Emory Blodgett,[1]	Fiskdale,	3 Fearing Street.
Heffron, Frederick,	Sherborn,	108 Pleasant Street.
Hogg, Lawrence Jagger,[1]	Lawrence,	Pease Avenue.
Howard, Louis Phillips,	North Easton,	19 Hallock Street.
Hutchinson, John Gouverneur,	Arlington,	15 South College.
Ingham, Earl Morris,	Granby,	86 Pleasant Street.
Jacobs, Loring Humphrey,[1]	Wellesley,	25 Pleasant Street.
Jenney, Herbert Hedge,[1]	South Boston,	6 Nutting Avenue.
Johnson, Rollin Eugene,[1]	Templeton,	120 Pleasant Street.
Jones, Dettmar Wentworth,[1]	Melrose,	66 Pleasant Street.
Leete, Richard Fowler,[1]	Mount Kisco, N. Y.,	81 Pleasant Street.
Levine, Henry Walter,[1]	Roxbury,	101 Pleasant Street.
Lincoln, Murray Danforth,	North Raynham,	19 Hallock Street.
Lucas, Hoyt Dennis,	West Springfield,	1 Allen Street.
Major, Joseph,	Rutherford, N. J.,	58 Pleasant Street.
Marsh, Frank Eugene,	Jefferson,	79 Pleasant Street.
Merkle, Frederick Grover,	Amherst,	North East Street.
Morrison, Harold Ivory,	Melrose,	77 Pleasant Street.
Morse, Harold John,[1]	Townsend,	75 Pleasant Street.
Needham, Lester Ward,[1]	Springfield,	Kappa Sigma House.
Nicolet, Theodore Arthur,[1]	Fall River,	Flint Laboratory.
Nicolet, Tell William,	Fall River,	C. S. C. House.
Nissen, Harry,	Boston,	85 Pleasant Street.
Norton, Leslie Howard,	Newport, R. I.,	79 Pleasant Street.
Nute, Raymond Edson,	Fall River,	9 Fearing Street.
Oertel, John Thomas,[1]	South Hadley Falls,	116 Pleasant Street.
Parker, Ervine Franklin,	Poquonock, Conn.,	Kappa Sigma House.
Payne, Roland Alfred,	Wakefield,	North Amherst.
Pellett, John Doubleday,	Worcester,	16 North College.
Peters, Chester Harry,	Brown's Station, N. Y.,	116 Pleasant Street.
Petersen, Peveril Oscar,[1]	Concord,	9 Fearing Street.
Porter, Bennett Allen,	Amherst,	Hatch Barn.
Powers, Richard Henry,[1]	Malden,	Veterinary Laboratory.
Read, Frederick William,[1]	Boston,	Telephone, Amherst, 380.
Reid, George Alexander,	Worcester,	Care of E. M. Dickinson.
Russell, Alden Hesseltine,	Watertown,	116 Pleasant Street.
Sahr, Gabriel Arthur,[1]	Boston,	15 Phillips Street.

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[1] Work incomplete.

Sherman, Joel Powers,	Hyannis,	9 South College.
Shirley, John Newton,	South Duxbury,	30 North Prospect Street.
Small, Francis Willard,[1]	North Truro,	120 Pleasant Street.
Smith, Leon Edgar,	Boston,	2 South College.
Smith, Leone Ernest,	Leominster,	116 Pleasant Street.
Stevens, Arthur Eben.	Brockton,	Beta Kappa Phi House.
Strange, Sarah Josephine,	Marshfield,	Draper Hall.
Tarbell, Munroe Gifford,[1]	Brimfield,	10 North College.
Taylor, Arthur Wright,	Feeding Hills,	3 Nutting Ave.
Taylor, Leland Hart,	Peabody,	13 South College.
Thurston, Arthur Searle,	Everett,	9 Fearing Street.
Tower, Alfred Leigh,	Sheffield,	120 Pleasant Street.
Upton, Ernest Franklin,	Salem,	Care of R. J. Watts.
Walker, Nathaniel Kennard,	Malden,	16 North College.
Walker, Raymond Philip,	Taunton,	83 Pleasant Street.
Warner, Raymond Winslow,	Sunderland,	77 Pleasant Street.
Webster, Louis Armstrong,	Blackstone,	82 Pleasant Street.
Weigel, Arthur George,	Lawrence,	Care of Captain Martin.
Wheeler, Chester Eaton,	Lowell,	87 Pleasant Street.
Whidden, Burton Clark,[1]	Townsend,	81 Pleasant Street.
Whippen, Charles Warren,	Lynn,	13 Phillips Street.
Wing, John Govan,[1]	Somerville,	116 Pleasant Street.
Wood, Henry Joseph,	Mendon,	82 Pleasant Street.

Sophomore Class.

Alden, Charles Harold,[1]	Amherst,	East Pleasant Street.
Allen, Francis Ellwood,	Melrose,	10 Allen Street.
Anderson, Herbert Henry,	Ware,	19 Pleasant Street.
Archibald, Herbert Hildreth,	Waltham,	Care of R. J. Watts.
Baird, Earle Fairbank,[1]	Waltham,	15 Beston Street.
Banister, Seth Warrener,	Westford,	14 Nutting Avenue.
Bartlett, Emory Haynes,[1]	Enfield,	12 Cottage Street.
Bartlett, Edward Russell,	Newburyport,	66 Pleasant Street.
Bartley, Hastings Newcomb,[1]	Sandwich,	66 Pleasant Street.
Bemis, Willard Gilbert,[1]	North Brookfield,	12 Cottage Street.
Bennett, John Ingram,	Boston,	66 Pleasant Street.
Bishop, Chester Allen,[1]	Peterboro, N. H.,	C. S. C. House.
Boyer, Edward Everett Hale,[1]	Lynn,	67 East Pleasant Street.
Braley, Merton Loring,	Rock,	52 Amity Street.
Bronson, Harold Julius,	Buckland,	Brooks Farm.
Brooks, Gardner Milton,	Newton,	8 Allen Street.
Buell, Frank Weed,[1]	Brooklyn, N. Y.,	83 Pleasant Street.
Buttrick, John Willard,	Melrose,	16 Nutting Avenue.
Cale, Gladstone Hume,[1]	West Springfield,	79 Pleasant Street.
Callard, John Case,[1]	Winthrop,	Care of President Butterfield.
Cande, Donald Hopkins,[1]	Pittsfield,	87 Pleasant Street.
Chase, Alexander Baxter, Jr.,	West Barnstable,	Clark Hall.
Churchill, Chester Albert,[1]	Brockton,	18 Nutting Avenue.
Clark, Ellis Fred,	Granby, Conn.,	Theta Chi House.
Clark, Saxon Dickinson,	Springfield,	19 Phillips Street.
Cleveland, Waldo Atwood,	Baldwinsville,	14 Nutting Avenue.
Clough, Maurice Joseph,	Needham,	84 Pleasant Street.
Dalrymple, Andrew Campbell,	Revere,	3 McClellan Street.
Damon, Leon Blanchard,	Melrose,	Nutting Avenue.
Day, George Allen,	Warren,	12 Cottage Street.
Dole, Sumner Alvord,	Bardwell's Ferry,	79 Pleasant Street.
Donnell, George Edwin,	Burlington,	East Experiment Station.
Doran, William Leonard,	North Dartmouth,	Plant House.
Draper, Earle Sumner,	Milford,	C. S. C. House.
Farrar, Stuart Kittridge,	Springfield,	Kappa Sigma House.
Fitzgerald, Daniel James,[1]	Worcester,	75 Pleasant Street.

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[1] Work incomplete.

Flebut, Alpha John,	Amherst,	27 McClellan Street.
Frost, Robert Theodore,	New York, N. Y.,	C. S. C. House.
Fuller, Richard,	Salem,	West Experiment Station.
Gare, Edward John, Jr.,[1]	Northampton,	13 Phillips Street.
Goodwin, Malcolm Noyes,	Newburyport,	Kappa Sigma House.
Graham, Lucius Henry,[1]	Boston,	Pleasant Street, care of Mrs. Clutia.
Grant, Harold Davidson,	Methuen,	3 McClellan Street.
Grebin, Mark Anthony,[1]	North Hadley,	North Hadley.
Griggs, Raymond Bradford,[1]	Chicopee Falls,	84 Pleasant Street.
Hall, George Morris,	Brookline,	31 East Pleasant Street.
Hall, Roderick Chesley,	Worcester,	79 Pleasant Street.
Harper, James Edward,	New Haven, Conn.,	Kappa Gamma Phi House.
Harper, Raymond Wires,	Barre,	94 Pleasant Street.
Harvey, Russell Wilton,[1]	Lanesville,	44 Pleasant Street.
Haskell, Willis Henry, Jr.,[1]	Brooklyn, N. Y.,	116 Pleasant Street.
Hatfield, William Hollis,	Wellesley,	87 Pleasant Street.
Hathaway, Isaac,[1]	Kingston,	96 Pleasant Street.
Hildreth, Paul Hughes,[1]	Newtonville,	8 Allen Street.
Hill, Charles Chase,[1]	Melrose Highlands,	Pease Avenue.
Hotis, Ralph P.,	Evans Mills, N. Y.,	20 Amity Street.
Hyde, George Frederic,	North Dana,	79 Pleasant Street.
Hyde, Harold Gilmore,	Winchendon,	36 North Prospect Street.
Johnson, Arthur,	Bridgeport, Conn.,	12 South College.
Jordan, Perley Balch,[1]	Topsfield,	15 Beston Street.
Kelleher, Jerome Joseph.	Montague City,	75 Pleasant Street.
Kennedy, Thomas James,	South Hadley Falls,	35 East Pleasant Street.
Kennedy, Worthington Chester,	Hardwick,	101 Pleasant Street.
Koplovitz, Samuel,	Chelsea,	29 Lincoln Avenue.
Lane, Merton Chesleigh,	South Duxbury,	Care of L. A. Root.
LeDuc, Ashley Cudworth,[1]	Chesterfield,	19 Pleasant Street.
Lewis, Daniel James,	Hanson,	Kappa Sigma House.
Lewis, John Kirby,[1]	New Haven, Conn.,	Care of E. M. Dickinson.
Lincoln, Irving Boin,[1]	Glens Falls, N. Y.,	Care of President Butterfield.
Little, Harold Greenleaf,[1]	Newburyport,	Kappa Sigma House.
Lovejoy, John Sumner,	Newburyport,	53 Lincoln Avenue.
MacNeil, Ralph Langdel,	Chelsea,	21 Amity Street.
Macy, Philip Arthur,	Oak Bluffs,	53 Lincoln Avenue.
Marsh, Franklin Winter,	Amherst,	16 Nutting Avenue.
Marsh, Herbert Verner,	Deerfield,	79 Pleasant Street.
Masse, Sidney Merton,	Dorchester,	3 McClellan Street.
McKechnie, Ray Farrar,	Natick,	5 McClellan Street.
McLain, Ralph Emerson,	Melrose,	66 Pleasant Street.
Melicau, George Deady,[1]	Worcester,	66 Pleasant Street.
Melloon, Ralph Reid,[1]	Lowell,	Kappa Sigma House.
Moberg, Eldon Samuel,	Campello,	18 Nutting Avenue.
Montague, Enos James,	Northampton,	13 Phillips Street.
Moore, Roger Henry,	Beverly,	66 Pleasant Street.
Navas, Miguel,[1]	Barranquilla, Col., S. A.,	120 Pleasant Street.
O'Brien, Daniel William,[1]	Wayland,	New Apiary.
Parker, Edwin Kenney,[1]	Northampton,	77 South Pleasant Street.
Parmenter, Ernest Brigham,[1]	Dover,	79 Pleasant Street.
Patten, Merrill Campbell,	Brighton,	31 East Pleasant Street.
Patterson, Robert Earley,	Dorchester,	75 Pleasant Street.
Pendleton, Harlow Libby,[1]	Dorchester,	16 Nutting Avenue.
Perry, Gerald Eugene,	Amherst,	Prospect House.
Pike, Joseph Stevens, Jr.,	Somerville,	3 Nutting Avenue.
Potter, George Raymond,[1]	Ludlow,	44 Pleasant Street.
Price, James Albert,	New York, N. Y.,	15 Beston Street.
Rhoades, Paul Whitney,	Malden,	2 Allen Street.
Rogers, Harold Merriman,	Southington, Conn.,	87 Pleasant Street.
Sauchelli, Vincent,	Waterbury, Conn.,	11 High Street.

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[1] Work incomplete.

Scott, Lincoln Bain,[1]	Melrose,	3 McClellan Street.
Sears, William Richard,	Arlington,	84 Pleasant Street.
Severance, Verne Lincoln,	South Hanson,	Care of L. A. Root.
Sherman, Milton Francis,	South Lincoln,	10 Allen Street.
Simon, Isaac Barney,[1]	Revere,	38 Cottage Street.
Slein, Owen Francis,	New Braintree,	127 South Pleasant Street.
Smith, Himan,[1]	Worcester,	8 Allen Street.
Spofford, Chester Porter,	Georgetown,	5 McClellan Street.
Strauss, Abraham,[1]	Boston,	101 Pleasant Street.
Taft, Richard Craig,[1]	Oxford,	84 Pleasant Street.
Tarr, Lester Winslow,[1]	Rockport,	44 Pleasant Street.
Tonry, Albert Joseph Paul,[1]	Winthrop,	Durfee Plant House.
Tower, Ralph Ernest,	Becket,	120 Pleasant Street.
Tower, William Reginald,	Sheffield,	94 Pleasant Street.
Towne, Edwin Chester,[1]	Waltham,	C. S. C. House.
Upton, Raymond Melville,	Peabody,	87 Pleasant Street.
Vener, Benjamin,	Brockton,	38 Cottage Street.
Vinal, Stuart Cunningham,	East Weymouth,	9 Allen Street.
Wellington, Benjamin,	Waltham,	10 Allen Street.
White, Homer Beethoven,	Melrose,	10 Allen Street.
White, Henry Harrison,	West Peabody,	79 Pleasant Street.
Whitmore, Philip Ferry,	Sunderland,	13 Phillips Street.
Whorf, Paul Francis,	Hyde Park,	87 Pleasant Street.
Wilkins, Alfred Emerson,	Wakefield,	116 Pleasant Street.
Willey, Harold Cleland Clancy,	Orange,	Care of E. F. Gaskill.
Williams, Donald,	Catasauqua, Pa.,	C. S. C. House.
Woodman, Edward, Jr.,[1]	Portland, Me.,	15 Gaylord Street.
Wright, Elvin Stanley,	Worcester,	15 Fearing Street.

Freshman Class.

Aiken, Harold,	Millis,	29 McClellan Street.
Allen, Chester King,	Quincy,	Brooks Farm.
Anderson, Frank Albert,[1]	Somerville,	13 Phillips Street.
Andrews, Francis Marshall, Jr.,	Manchester,	53 Lincoln Avenue.
Barnes, Fred Leslie,	Plymouth,	7 Nutting Avenue.
Bean, Harold John,[1]	Haverhill,	Care of E. F. Gaskill.
Beeler, Leon Charles,[1]	Adams,	75 Pleasant Street.
Bishop, Herbert Walker,[1]	Doylestown, Pa.,	C. S. C. House.
Bisbee, Philip Emerson,	Waitsfield, Vt.,	East Pleasant Street.
Blanpied, Nelson Uhler,	Framingham,	Care of Mr. Forristall.
Bradley, William George,	Groton,	31 East Pleasant Street.
Brazil, William Henry,	Leominster,	116 Pleasant Street.
Brush, David Carey,	Vineyard Haven,	19 Phillips Street.
Burnham, Chester Arthur,	Westford,	Brooks Farm.
Burt, Warner Howard,	Longmeadow,	6 Nutting Avenue.
Caldon, John Jeremiah,	West Springfield,	– –
Caldwell, Harold Nute,	Lowell,	3 Nutting Avenue.
Cardarelli, Emilio Joseph,	Boston,	31 North Prospect Street.
Carruth, Glenn Howard,	Orange,	34 North Prospect Street.
Carver, Frank Whitney,	Plymouth,	7 Nutting Avenue.
Cate, Rex March,	Canton,	3 Nutting Avenue.
Chamberlin, Raymond,	Rutherford, N. J.,	82 Pleasant Street.
Chisholm, Raymond Lincoln,	Melrose Highlands,	66 Pleasant Street.
Choate, Carlisle Edward,	Boston,	15 Phillips Street.
Clapp, Raymond Luckey,[1]	Northfield,	Brooks Farm.
Clough, Charles Henry,	Dedham,	35 East Pleasant Street.
Cobban, Donald Stickney,[1]	Groveland,	Mt. Pleasant.
Coleman, Albert Sumner,	Mendon,	15 Hallock Street.
Coley, William Stanton,	Wilton, Conn.,	36 North Prospect Street.
Courchene, Alcide Telesphor,[1]	North Adams,	14 Nash Block.
Curran, Harry Ambrose,	Marlborough,	Taylor Farm.

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[1] Work incomplete.

Curtin, Charles Warren,	Auburndale,	15 Hallock Street.
Cushing, Raymond Alonzo,	Somerville,	13 Phillips Street.
Danforth, George Newlan,	Foxcroft, Me.,	82 Pleasant Street.
Davis, Frank Leslie,	South Hopedale,	Care of E. F. Gaskill.
Dickinson, William Cowls,	North Amherst,	North Amherst.
Dine, Hyman Bertram,	Boston,	35 South Pleasant Street.
Dinsmore, Donald Sanderson,	Springfield,	6 Nutting Avenue.
Doggett, William Henry,[1]	Dedham,	35 East Pleasant Street.
Doherty, Paul Edward,[1]	Fall River,	East Pleasant Street.
Duffill, Edward Stanley,[1]	Greenwood,	Care of L. A. Root.
Dumas, Walter Branca,[1]	Boston,	35 East Pleasant Street.
Dunbar, Henry Hart,	Taunton,	83 Pleasant Street.
Edwards, Maurice Millett,	Lawrence,	25 Pleasant Street.
Eldredge, Raymond Chase,	No. Abington,	30 North Prospect Street.
Eldridge, Clarence Crocker,	Natick,	52 Lincoln Avenue.
Epstein, Harry Browdy,	Amherst,	38 Cottage Street.
Fernald, Charles Henry,	Amherst,	44 Amity Street.
Fielding, Lester Edward,	Malden,	2 Allen Street.
Fisher, George Basil,	Millbury,	Care of E. F. Gaskill.
Fox, Edward Lawrence,[1]	Winthrop,	29 McClellan Street.
Francis, Charles Davis,	Cranford, N. J.,	25 Pleasant Street.
Gaventa, Harry Reymer	Repaupo, N. J.,	35 East Pleasant Street.
Gilmore, Benjamin Anthony,	Acushnet,	40 Amity Street.
Gioiosa, Alfred Anthony,	Dorchester,	Brooks Farm.
Glover, Theodore Whitford,	South Duxbury,	Care of L. A. Root.
Goodwin, Clinton Foster,	Haverhill,	7 Nutting Avenue.
Googins, Burton,	Brooklyn,	52 Lincoln Avenue.
Gordon, Lewis Sanford, Jr.,	Clinton,	Care of Dr. Gordon.
Gould, Charles Holt,[1]	Worcester,	66 Pleasant Street.
Graves, Ralph Wheeler,	Shelburne Falls,	40 Amity Street.
Gray, Frank Lyman,	Shelburne Falls,	North Amherst.
Gunn, Carlton Merrick,	Sunderland,	3 Nutting Avenue.
Hager, Clayton Marden,	Somerville,	3 Nutting Avenue.
Hall, Stanley William,	Saxonville,	Brooks Farm.
Harlow, Nathaniel Luzerne,[1]	Amherst,	7 Parsons Street.
Harriman, Chester Karl,	Exeter, N. H.,	36 North Prospect Street.
Harris, William Lombard, Jr.,	Deerfield,	53 Lincoln Avenue.
Harrocks, Thomas Lincoln,	Westminster,	36 North Prospect Street.
Hart, Reginald,	Montague City,	53 Lincoln Avenue.
Haskell, Frank Eugene,	Northborough,	Care of C. R. Greene.
Hathaway, Charles Edward,	Somerset,	19 Phillips Street.
Hemenway, Justin Stanley,	Williamsburg,	Brooks Farm.
Hendry, Arthur Ekman,[1]	Mattapan,	16 Nutting Avenue.
Hobart, Ralph Edmund,	North Amherst,	North Amherst.
Holden, Mae Faustina,	Royalston,	Care of President Butterfield.
Hulsizer, Allan Lynne,	Flemington, N. J.,	29 North Prospect Street.
Hunt, Reginald Stuart,	Bridgewater,	53 Lincoln Avenue.
Huntington, Charles Albert, Jr.,	Poquonock, Conn.,	82 Pleasant Street.
Jenna, William Wallace,[1]	Athol,	116 Pleasant Street.
Jerome, Frederick William,[1]	Stockbridge,	40 Amity Street.
Jones, Linus Hale,	Milford,	Care of C. R. Greene.
Kaplan, Barney,	Malden,	38 Cottage Street.
Keegan, Frank Champion,[1]	Turners Falls,	75 Pleasant Street.
Keegan, Thomas Michael,[1]	Worcester,	75 Pleasant Street.
Kelly, Harold Russell,	Haverhill,	15 Gaylord Street.
Kennedy, George William,	Sayville, L. I.,	7 Nutting Avenue.
Kilbon, Ralph Gillette,[1]	Springfield,	Brooks Farm.
King, Edward Lee,	Dorchester,	Brooks Farm.
Kinsman, Alfred Oberlin, Jr.,	Merrimac,	– –
Kitsis, Henry Hyman,[1]	Boston,	41 Pleasant Street.
Knapton, Guy Lord,	Lawrence,	Pease Avenue.
Laird, Kenneth Bradford,	Brockton,	36 North Prospect Street.

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[1] Work incomplete.

Lamoureux, Domina Joseph,	Adams,	75 Pleasant Street.
Lehman, Walter Ernest,	Worcester,	East Pleasant Street.
Lieber, Conrad Hugo,[1]	Jamaica Plain,	31 North Prospect Street.
Lindquist, Albert Evert,[1]	Jamaica Plain,	5 McClellan Street.
Locke, Wilbur Trow,	Lawrence,	25 Pleasant Street.
Lyford, Waldo Preston,	Natick,	52 Lincoln Avenue.
MacDonald, Norman Duncan,	Melrose,	College Store.
Mahony, William John,	Winthrop,	29 McClellan Street.
Mann, Victor Leslie,	Millers Falls,	13 Phillips Street.
Marshall, Earl LeForest,	Neponset,	Hadley.
Mattoon, Harold Gleason,	Pittsfield,	87 Pleasant Street.
Maynard, Harlan Slade,[1]	Jefferson,	Care of R. J. Goldberg.
McCulloch, Norman Estes,	Pawtucket, R. I.,	Care of Professor Morton.
Meade, Joseph Williams,[1]	West Springfield,	Care of Mrs. Hill, Nutting Avenue.
Mimitz, Joseph Raymond,[1]	Hadley,	Hadley.
Montgomery-Peter, Thomas M.,	Philadelphia, Pa.,	15 Phillips Street.
Mooney, Raymond A.,[1]	Plattsburgh, N. Y.,	12 Hallock Street.
Morton, Walter Joseph,[1]	Jamaica Plain,	Care of Mrs. Gibbs.
Moses, Charles Wicker,	Ticonderoga, N. Y.,	7 Nutting Avenue.
Moss, Earle Chester,[1]	Worcester,	Care of Mrs. Gibbs.
Mostrom, Harold Augustus,	Somerset,	36 North Prospect Street.
Murphy, John William,	Beverly,	15 Beston Street.
Nash, Clayton Wells,	South Weymouth,	7 Nutting Avenue.
Nestle, William John,[1]	Amherst,	Amherst.
Nicholson, James Thomas,	Leominster,	116 Pleasant Street.
Noyes, Samuel Verne,[1]	Georgetown,	36 North Prospect Street.
O'Brion, Edwin Fulton,	Somerville,	83 Pleasant Street.
Oertel, August Leonard,[1]	South Hadley Falls,	South Hadley Falls.
Palmer, George Bradford,	Brookline,	Care of E. F. Gaskill.
Phelps, Sanford Wallace,	Turners Falls,	35 East Pleasant Street.
Pierce, James Dwight,[1]	Springfield,	Care of E. H. Forristall.
Plaisted, Philip Asbury,	Arlington,	77 Pleasant Street.
Porter, Philip Clayfield,	West Springfield,	79 Pleasant Street.
Potash, Philip,[1]	Boston,	35 South Pleasant Street.
Potter, David,	Concord,	40 Amity Street.
Pratt, Walter Howard,	Dalton,	Hallock Street and Pease Avenue.
Prouty, Stanley Marshall,	North Brookfield,	12 Cottage Street.
Quincy, Knight,	Roslindale,	35 East Pleasant Street.
Randall, Denton William,	Somerville,	– –
Ray, George Burrill,	Hingham,	Brooks Farm.
Reed, Andrew John, Jr.,	Dalton,	Pease Avenue.
Rendall, Raymond Eaton,	Melrose,	College Store.
Rich, Gilbert Warren,	Hingham,	8 Allen Street.
Richards, Everett Stackpole,	Northampton,	Northampton.
Richardson, Lewis Elmer,	Millis,	29 McClellan Street.
Ricker, Dean Albert,	Worcester,	C. S. C. House.
Rogers, Roland Winsor,[1]	Roxbury,	25 Lincoln Avenue.
Rogers, Tyler Stewart,	Saxonville,	Care of Mr. Forristall.
Rowe, Louis Victor,[1]	Melrose,	18 Nutting Avenue.
Russell, Ernest Samuel,	Hadley,	Hadley.
Ryan, William Edward, Jr.,[1]	Stoughton,	7 Nutting Avenue.
Sanderson, Everett Shovelton,	Centreville, R. I.,	19 Phillips Street.
Saunders, William Putnam,	Lawrence,	1 Allen Street.
Sauter, William Hugo,[1]	Turners Falls,	75 Pleasant Street.
Scheufele, Frank Joseph,	South Natick,	52 Lincoln Avenue.
Schlotterbeck, Lewis,[1]	Roxbury Station, Conn.,	12 Hallock Street.
Schwartz, Louis,	Melrose,	38 Cottage Street.
Shapiro, Frank Simon,	Lynn,	41 Pleasant Street.
Sherinyan, Suran Donald,	Worcester,	Care of Mrs. Taylor, North Amherst.

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[1] Work incomplete.

Simmons, Perez,[1]	Pittsfield,	36 North Prospect Street.
Smith, Horace Arthur,[1]	Newtown, Conn.,	Care of Mrs. Gibbs.
Smith, Philip Laurence,	Kingston,	Care of Mrs. Gibbs.
Stanford, Ernest Elwood,	Rowe,	71 South Pleasant Street.
Stearns, Frederick Campbell,	Waltham,	40 Amity Street.
Stone, Albert Edwin,[1]	Worcester,	Brooks Farm.
Stoughton, Richard,	Montague,	21 Fearing Street.
Swan, Durelle,	Dorchester Centre,	Care of Professor Morton.
Swift, Raymond Walter,	North Amherst,	North Amherst.
Taber, Ralph Fred,	Phoenix Mills, N. Y.,	77 Pleasant Street.
Tarbell, Herbert Hitchcock,[1]	Warren,	12 Cottage Street.
Taylor, Howell,[1]	Florida, N. Y.,	7 Nutting Avenue.
Topham, Alfred,	Lawrence,	31 East Pleasant Street.
Treat, Rutherford Sperry,	Seymour, Conn.,	7 Nutting Avenue.
Upham, Thomas Carlton,	Fitchburg,	15 Hallock Street.
Verbeck, Howard Graves,[1]	Malden,	Care of C. R. Greene.
Walkden, Herbert Haldon,	Westford,	Brooks Farm.
Walker, Henry Marshall,	South Harwich,	Brooks Farm.
Walker, Robert Russell,	Mansfield,	– –
Warner, Lewis Pomeroy,[1]	Sunderland,	3 Nutting Avenue.
Webster, Frank Cedric,	Harvard,	35 East Pleasant Street.
Weisbein, Isaac,	Brooklyn, N. Y.,	Care of L. A. Root.
Wells, Harry Andrew,	Dalton, Pa.,	5 McClellan Street.
Wentworth, Everett Lawrence,	East Dover, Vt.,	30 North Prospect Street.
Wetherbee, Raymond Scott,	Waltham,	35 East Pleasant Street.
Wheeler, Chester Warren,	Southborough,	28 Northampton Road.
Wheeler, Robert Kellogg,	Great Barrington,	40 Amity Street.
Whitney, Leon Fradley,	Brooklyn, N. Y.,	52 Lincoln Avenue.
Whitney, Harold Tichenor,	Mt. Vernon, N. Y.,	C. S. C. House.
Wies, Calmy,[1]	Malden,	38 Cottage Street.
Wilcox, Timothy Palmer,	Andover,	83 Pleasant Street.
Wildon, Carrick Earl,	Melrose,	66 Pleasant Street.

Unclassified Students.

Bates, L. Emeline,	Billerica,	Draper Hall.
Blackhall, Allan John,	Brookline,	Care of Professor Morton.
Cann, Fred Hodges,	Beverly,	44 Triangle Street.
Cannon, Thomas Vincent,	Newton,	77 Pleasant Street.
Chambers, Maude Burdick,	Harper's Ferry, W. Va.,	8 Allen Street.
Comeau, Mark Walter,	Maynard,	19 Pleasant Street.
Crosby, Stanley,	Warren,	Theta Delta Chi House.
Dearth, Newman,	Ashland,	35 East Pleasant Street.
Dillon, Thomas Stevenson,	West Warren,	101 Pleasant Street.
Dodd, Dexter Tiffany,	Chestnut Hill,	83 Pleasant Street.
Dodge, Walter Eugene,	Geneva, O.,	14 South College.
Fiske, Howard Benjamin,	Passaic, N. J.,	Care of Professor White.
Fitzgerald, William Patrick,	Worcester,	75 Pleasant Street.
Fox, Everett Bailey,	Dracut,	3 Nutting Avenue.
Hicks, Albert James,	Northfield,	Brooks Farm.
Hooper, Edward Asa,	Chestnut Hill,	36 North Prospect Street.
Kendall, Edward Dana,	Holden,	Brooks Farm.
Lockwood, Dimon,	Boston,	Prospect House.
Malkasian, Nishan P.,	Boston,	– –
MacCormac, Wm. Frederic,	Malden,	Brooks Farm.
Mott, Percival,	Cambridge,	81 Pleasant Street.
Nixon, William Joseph,	Boston,	101 Pleasant Street.
Pease, Willard Noah Morris,	Altoona, Pa.,	Brooks Farm.
Perry, Edgar Adams,	Attleborough,	35 East Pleasant Street.
Prouty, LeRoy Fletcher,	Rockland,	31 North Prospect Street.
Rae, George Little,	Needham Heights,	2 Allen Street.
Richards, Edwin Henry,	Hartford, Conn.,	2 Allen Street.

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[1] Work incomplete.

Ridlon, Ernest Tarr,	Chelsea,	15 Gaylord Street.
Taylor, Frank Reed,	Frye, Me.,	30 North Prospect Street.
Willard, Harold Nelson,	Baltimore, Md.,	81 Pleasant Street.
Winkler, Alfred,	Hackensack, N. J.,	44 Triangle Street.

SHORT COURSES.

Ten Weeks' Registration.

Abbot, Mary Perkins,	5 Marlboro Street, Boston.
Allen, Walter J.,	Box 76, Berlin.
Badger, Jos. J.,	Hudson.
Baker, Chas. L.,	8 St. James Street, Boston.
Baldwin, Chas. H.,	75 Pearl Street, Boston.
Barker, Bowen,	85 Forest Hills Street, Jamaica Plain.
Barnard, Ernest K.,	Grasmere, N. H.,
Bartlett, Allen J.,	Lenox.
Bates, Harold,	Oxford.
Bigelow, Jos. S., Jr.,	Cohasset.
Bittinger, Fritz John,	Plymouth.
Blodgett, W. K.,	South Lincoln.
Borden, Aulrey W.,	South Framingham.
Boyd, Gardner,	Dedham.
Bresth, Samuel,	West Acton.
Brewer, Leon Arthur,	Berlin.
Browne, W. Prichard,	New York City.
Caldwell, Delmont,	Dorchester.
Campbell, Ronald,	Wayland.
Cartier, Frank J.,	Mittineague.
Chapman, Mortimer,	Richmond.
Chase, Chas. S.,	Foxborough.
Clary, Dennis J.,	Holyoke.
Coffin, Paul S.,	Boston.
Colburn, Edw.,	New Boston, N. H.
Cole, Harold W.,	Greenbush.
Condon, E. F.,	Great Barrington.
Cooley, Elbert,	New York.
Cooper, Herbert M.,	Interlaken.
Cotton, Harvey,	Brighton.
Crowley, Jos.,	Cushman.
Cushman, Julian H.,	Bernardston.
Dale, Fred,	Manchester.
Davis, H. W.,	Greenfield.
Davis, Walter H.,	Amherst.
Davison, Geo. E.,	Malden.
Deady, Nona E.,	South Boston.
Decatur, Jos. H.,	Wayland.
Easterbrook, I. H.,	Dudley.
Eastman, Harold,	South Lyndeboro, N. H.
Farrar, A. D.,	Amherst.
Feeney, John, Jr.,	Westford.
Fiebiger, Peter,	Weehawken, N. J.
Fisher, Walter H.,	Barre.
Fisher, E. J.,	Falmouth.
Ford, Earl Jay,	Stockbridge.
Francis, Benj. A.,	Rock.
Freeman, Jos. O.,	Dana.
French, Mrs. Mary B.,	Acworth, N. H.
Gleason, Ray E.,	Dell.
Gopan, Sylvester,	Tarrytown, N. Y.
Greene, Maurice N.,	Amherst.
Groff, Julya,	Amherst.
Grosvenor, Wm. H.,	Auburn.
Gummow, Earl,	Halifax.
Hakes, Chauncey,	Stockbridge.

Hall, C. John,	Milton.
Harris, Myron A.,	Farmington, Conn.
Hawks, Paul,	Deerfield.
Hendrickson, M. Louise,	Pittsfield.
Holbrook, Lewis,	Brooks' Farm, Amherst.
Howes, Leon G.,	Watson.
Ihmsen, Chas. B.,	Providence, R. I.
Imlay, Manning P.,	Zanesville, O.
Jenks, E. Lawrence,	Adams.
Johnson, Raymond F.,	North Grafton.
Jordan, Earl W.,	West Newbury.
Jones, Chapin,	Tufts College.
Judd, Robt. S.,	South Hadley.
Kendall, E. Dana,	Holden.
Kentfield, John T.,	Amherst.
Lathe, Martha L.,	Newton.
Lawrence, Wm. G.,	Lincoln Street, Hudson.
Leach, C. Arthur,	South Hamilton.
Leithauser, G. C.,	Bloomfield, N. J.
Lerner, Rose,	Peru.
Lillie, Walter P.,	Peace Dale, R. I.
Macken, Michael,	Glendale.
Manton, Geo., Jr.,	Eglinton, Ont.
Martell, Jos. A.,	Southbridge.
McGill, Edg. J.,	Beverly.
McGregor, Frank,	Newburyport.
Mead, Harlow E.,	North Andover.
Melloon, Ralph Reid,	Lowell.
Messerli, R. A.,	West Andover.
Mezit, Peter,	Damascus, Va.
Moyle, John, Jr.,	Groton.
Nash, Henry C.,	Amherst.
Newton, Lola J.,	West Brattleboro, Vt.
Newton, R. Alb.,	West Brattleboro, Vt.
North, John,	Richmond.
O'Connor, Raymond L.,	Jamaica Plain.
Paley, Israel,	Colchester, Conn.
Palmer, Florence E.,	Chestnut Hill.
Parker, Priscilla,	100 Blue Hills, Hartford, Conn.
Paulson, Jos. W.,	Meadowwood Farms, Cazenovia, N. Y.
Pearson, Edw.,	Fairhaven.
Pease, Clarence A.,	Meriden, Conn.
Poor, Benj. P.,	North Andover.
Prentice, Mrs. I. S.,	Springfield.
Prentice, I. S.,	Springfield.
Prescott, E. Clyde,	Westford.
Putnam, Earl F.,	Easthampton.
Priest, Karlton K.,	Littleton.
Reed, Frank H.,	Greenwich, Conn.
Rosen, Morris,	Brockton.
Sabine, Stephen W.,	Brookline.
Sanford, Earle,	Springfield.
Simmons, Geo. Slate,	Brooklyn, N. Y.
Simmons, G. W.,	Amherst.
Shaylor, F. W.,	Lee.
Smith, E. Parker,	Holliston.
Smith, John A.,	South Westport.
Snow, Linus A.,	Windsor, Conn.
Snow, Inez J.,	Windsor, Conn.
Story, Myron,	Chester.
Talbot, H. S.,	South Hadley.
Tate, Raymond C.,	Monterey.
Tufts, Wm.,	Boston.

Turner, Harvey,	North Reading.
Walker, Raymond,	Greenwich Village.
Wall, Geo. W.,	Chester, Pa.
Warburton, Chatterton, Jr.,	Fall River.
Webber, Harold T.,	Winchester.
Wetmore, C. Inglis,	Wollaston.
Wheeler, Caleb H.,	Concord.
Whitby, Lawrence,	Northborough.
Wilson, Wm. F.,	Orford, N. H.
Wiswall, Geo. W.,	Newton Centre.
Wiswall, Ralph A.,	Newton Centre.
Worthen, Stewart,	Mittineague.

Apple Packing School.

Abbot, M. P.,	Boston.
Bigelow, Jos. S., Jr.,	Cohasset.
Boyd, Gardner,	Dedham.
Brown, F. Howard,	Marlborough.
Browne, W. P.,	New York City.
Clark, Winslow,	Shoreham, Vt.
Cobb, Geo. R.,	Kingston, R. I.
Colburn, Edw. N.,	New Boston, N. H.
Cole, Harold W.,	Greenbush.
Condon, C. F.,	Great Barrington.
Critchett, E. R.,	Amherst.
Crocker, B.,	Morristown, N. J.
Davenport, S. L.,	North Grafton.
Dickson, Walter A.,	Harvard.
Easterbrook, I. H.,	Dudley.
Granger, Helen,	Griswoldville.
Green, C. R.,	Belchertown.
Kendall, E. D.,	Holden.
Leach, C. Arthur,	South Hamilton.
Lord, W. E.,	Newfield, Me.
McGill, Edg. J.,	Beverly.
Mead, H. E.,	North Andover.
Messerli, R. A.,	West Andover.
Munson, Wm. A.,	Littleton.
Paul, R. A.,	Framingham.
Paulson, J. W.,	Cazenovia, N. Y.
Prentice, I. S.,	Springfield.
Putnam, E. F.,	Easthampton.
Reynolds, L. J.,	Greenwich, Conn.
Rogers, Geo. L.,	North Wilbraham.
Sabin, Leroy C.,	Ipswich.
Sabine, S. W.,	Brookline.
Shattuck, Mrs. B. B.,	West Acton, Mass.
Taylor, E. R.,	Stow, Mass.
Tufts, Wm.,	Boston.
Walker, R. C.,	Greenwich, Conn.
Wallace, Wm. N.,	Amherst.
Webber, H. T.,	Winchester.
Wheeler, C. N.,	Concord.
Whitby, L. H.,	Northborough.

Beekeeping Course.

Belleville, W. E.,	South Chelmsford.
Churchill, Clarence,	Lynn.
Dayton, Louise M.,	Boston.
Hartwell, Harriet,	Boston.
Howland, Florence B.,	Revere.
Lockwood, D.,	Amherst.

Robie, H. W.,	Winona, N. H.
Williams, Mrs. Ada B.,	Nahant.
Wojcik, Rev. James,	Springfield, N. Y.
Wood, Lawrence,	Amherst.

Poultry Course.

Abbott, George H.,	Brookline.
Adams, Rev. W. H.,	Southampton.
Allis, Mrs. R. D.,	Amherst.
Allis, Rufus D.,	Amherst.
Barker, Arthur C.,	Boston.
Barnes, Mrs. Ralph,	Andover.
Bosworth, W. D.,	North Orange.
Brewer, Mrs. A. A.,	Southampton.
Brigham, Henry,	Northampton.
Brooks, A. A.,	Holyoke.
Brown, Geo. A.,	Amherst.
Browne, L. L.,	New York, N. Y.
Burnett, W. A.,	South Hadley.
Byam, Mrs. D. H.,	Mansfield.
Challis, H. E.,	South Hadley.
Childs, Emily F.,	Manomet.
Childs, P. B.,	Manomet.
Churchill, Mrs. Wm. W.,	Milton.
Clark, H. H.,	Billerica.
Clark, Norman,	Sunderland.
Corliss, Oscar L.,	Belchertown.
Cressey, George B.,	Salem.
Davis, Mrs. E. H.,	Amherst.
Doggett, Mary C.,	Dedham.
Doggett, T. T.,	Dedham.
Eldidge, Mrs. A.,	Amherst.
Estabrook, O. B.,	Hopedale.
Flagg, Helen L.,	West Acton.
Forristall, Mrs. E. H.,	Amherst.
Garabed, Mrs. D.,	Worcester.
Gold, M. D.,	Amherst.
Goodnow, J. S.,	Amherst.
Griswold, A. W.,	Elmwood, N. H.
Griswold, W. P.,	Holyoke.
Gunn, Chas. I.,	Sunderland.
Gunn, L. M.,	Sunderland.
Hack, Rev. Rollin T.,	Housatonic.
Harrison, Mrs. Walter H.,	Lebanon Springs, N. Y.
Harrison, Walter H.,	Lebanon Springs, N. Y.
Haven, Alta M.,	Mansfield.
Hawthorn, Peter,	Amherst.
Herrick, Ralph C.,	Hollis, N. H.
Hitchcock, Mary M.,	Ware.
Hodder, Mrs. A. R.,	Hadley.
Hooper, Mrs. W. H.,	East Milton.
Hyde, Elizabeth,	Ware.
Jacobs, D. I.,	Wellesley.
Jones, E. A.,	New Canaan, Conn.
Knowles, Rev. Samuel,	Lexington.
Lewis, I. C.,	Ulysses, Pa.
Lyon, Clarence W.,	South Weymouth.
Mayerison, T. Sydney,	Lawrence.
Messier, A. E.,	Amherst.
Miller, H. B.,	South Hadley.
Miskell, T. L.,	Brookline.
Moody, F. W.,	Rutland.
Morgan, Susie P.,	Amherst.

Morse, John E.,	Hadley.
Neil, James J.,	Lawrence.
Northan, H. H.,	Westfield.
Parsons, W. E.,	New Hartford, Conn.
Pease, Mrs. E. E.,	Granby.
Pease, E. E.,	Granby.
Perkins, Maude,	Newburyport.
Rice, W. A.,	South Hadley Falls.
Richardson, Harriet,	South Hadley.
Rood, Frank W.,	Southampton.
Shaw, Wm. E.,	Belchertown.
Smith, Louis E.,	Salem.
Stuart, H. W.,	Amherst.
Sturgis, Mrs. Edward,	Andover.
Talbot, H. S.,	South Hadley.
Thayer, Mrs. C. H.,	Amherst.
Thayer, H. A.,	Holyoke.
Speight, Thomas,	East Longmeadow.
Torrey, E. D.,	Easthampton.
Warner, Merrill,	Sunderland.
Warner, Robt. G.,	Florence.
White, Mrs. E. S.,	Roxbury.
Wolcott, Oliver,	East Longmeadow.

SUMMARY BY CLASSES.

Graduate students,	21
Senior class,	93
Junior class,	102
Sophomore class,	125
Freshman class,	184
Unclassified students,	31
Total registration,	556

GEOGRAPHICAL SUMMARY.

Massachusetts,	473
New York,	26
Connecticut,	20
New Jersey,	9
Pennsylvania,	5
New Hampshire,	4
Vermont,	4
Maine,	3
Rhode Island,	3
Barbados,	1
Colombia, S. A.,	1
Iowa,	1
Kentucky,	1
Maryland,	1
Mexico,	1
Ohio,	1
Virginia,	1
West Virginia,	1
Total,	556

GRADUATE STUDENTS — CANDIDATES FOR A DEGREE.

Ackerman, Arthur John, B.Sc., Massachusetts Agricultural College, 1912.	Worcester.
Anderson, David Wadsworth, B.Sc., New Hampshire State College, 1910.	Manchester, N. H.
Bourne, Arthur Isreal, A.B., Dartmouth College, 1907.	Kensington, N. H.
Davis, Irving Wilder, B.Sc., Massachusetts Agricultural College, 1911.	Lowell.
Fowler, George Scott, B.Sc., Massachusetts Agricultural College, 1912.	Wayland.
Gates, Rupert Granville, Ph.B., Sheffield Scientific School, 1912.	Northampton.
Gilbert, George Henry, Ph.B., Boston University, 1901.	Boylston.
Hall, Russell Bertram, B.Sc., Amherst College, 1912.	Worcester.
Hutson, John Coghlan, B.A., Oxford University, 1909.	Bridgetown, Barbados.
Martin, James Francis, B.Sc., Massachusetts Agricultural College, 1912.	Amherst.
Morse, Henry Bowditch, B.Sc., Massachusetts Agricultural College, 1911.	Salem.
Noyes, Harry Alfred, B.Sc., Massachusetts Agricultural College, 1912.	Marlborough.
Parker, Ralph Robinson, B.Sc., Massachusetts Agricultural College, 1912.	Malden.
Ruprecht, Rudolf William, B.Sc., Rhode Island State College, 1911.	Brooklyn, N. Y.
Richardson, Francis Allen, S.B., Harvard University, 1896.	Boston.
Smulyan, Marcus Thomas, B.Sc., Massachusetts Agricultural College, 1909.	Amherst.
Thomas, Frank Lincoln, B.Sc., Massachusetts Agricultural College, 1910.	Athol.
Tower, Daniel Gordon, B.Sc., Massachusetts Agricultural College, 1912.	Roxbury.
Turner, Howard Archibald, B.Sc., Massachusetts Agricultural College, 1912.	Dorchester.
Watkins, John Bedford, B.Sc., Virginia Polytechnic, 1911.	Midlouthian, Va.
Wehle, Harry Brandeis, A.B., Harvard University, 1910.	Louisville, Ky.

GRADUATE STUDENTS — NOT CANDIDATES FOR A DEGREE.

Eaton, Marion Goodwin, A.B., Radcliffe College, 1910.	Sudbury.
Rand, Frank Prentice, A.B., Williams College, 1912.	Worcester.

SUMMER SCHOOL REGISTRATION, 1911.

Aldrich, Helen,	Dorchester.
Allen, Mrs. Jas. A.,	Holyoke.
Allis, Mrs.,	Amherst.
Baker, Oliver A.,	Kingston.
Barry, Mary,	Amherst.
Bartlett, Mrs. Eugene,	Chicago, Ill.
Bartlett, Rev. Eugene,	Chicago, Ill.
Beaumont, Louise M.,	Worcester.
Belcher, S. Elizabeth,	Worcester.

Bennett, Alfred C.,	New York City.
Blanchard, Lucile M.,	North Uxbridge.
Bonsfield, Mary,	North Adams.
Boyd, Gardner,	Dedham.
Bradlee, Thomas,	Northampton.
Burke, E. G.,	Holyoke.
Burnham, Jessie E.,	Waltham.
Butcher, Gertrude,	Roxbury.
Carosella, Alfredo,	University of Pennsylvania, Philadelphia.
Car, Helen F.,	Boston.
Case, Myra W.,	West Hartford, Conn.
Chalmers, Helen,	New York.
Chalmers, Mary,	New York.
Cheney, Hazel Chase,	Amherst.
Chow, T. K.,	Amherst.
Church, Florence A.,	New York City.
Clark, Anna M.,	New York City.
Cleaveland, M. N.,	East Boxford.
Cole, Wm. Morton,	Newton Highlands.
Cölln, Miss M. Von,	Columbus, O.
Cushman, Mrs. F. P.,	Springfield.
Cushman, F. P.,	Springfield.
Dame, Daisy G.,	West Medford.
Dame, Mrs. Lorin L.,	West Medford.
Dibble, Mrs. Gertrude,	New York City.
Dimick, Julian A.,	East Corinth, Vt.
Doherty, Daniel F.,	Dorchester.
Eldidge, Mrs. Lizzie,	Amherst.
Epstein, Frances,	Amherst.
Epstein, Ida A.,	Amherst.
Evans, Augusta D.,	Northampton.
Farley, Chas. Judd,	Wellesley Hills.
Farnsworth, Earl H.,	Norwood.
Fisher, Georgina O.,	Cambridge.
Foley, Daniel,	Brighton.
Foster, Mr. C. W.,	Leominster.
Fox, Sarah E.,	Cohasset.
Gere, Robt. W.,	Springfield.
Gerould, Mrs. C. W.,	Cambridge.
Gerould, Chas. W.,	Cambridge.
Goodnow, Edna,	Amherst.
Gregory, E. S.,	Somerville.
Groff, J. G.,	Amherst.
Hall, E. Josephine,	Waltham.
Hea, Emily N.,	Medford.
Heidenheim, Hannah,	Brooklyn, N. Y.
Hewins, Alice E.,	Dedham.
Hidden, Mrs. W. H.,	Cambridge.
Hidden, W. H., Jr.,	Cambridge.
Holloway, Rev. Wm. H.,	Thomasville, Ga.
Howard, Mildred,	North Amherst.
Hoyt, Mrs. Laura A.,	Greenfield.
Hurd, Mrs. Wm.,	Amherst.
Johnson, Bertha L.,	Bristol, Conn.
Kellogg, Ella,	North Amherst.
Kennedy, H. A.,	East Weymouth.
Levin, Ethel,	Amherst.
Liang, F. T.,	Amherst.
Liang, Yii Cho,	Amherst.
Lew, Gerard N.,	Amherst.
Lovell, Mary E.,	Wayland.
Lyman, Harriet E.,	Boston.
Macdonald, Chas. D.,	New York City.

McKeen, Mrs. Teresa F.,	Allston.
Macomber, Lucy S.,	North Westport.
Maloney, Margaret,	Amherst.
Manoukian, V. M.,	Boston.
March, Mrs. Clement,	Arlington.
Matthews, Enid,	Cambridge.
Mills, Mabelle,	Amherst.
Mumma, C. H.,	Holyoke.
Nickerson, Charlotte,	Amherst.
Ostrolenk, Theresa,	Amherst.
Pabodie, Mrs.,	Hartwell, O.
Pabodie, Wm.,	Hartwell, O.
Perry, Sylvia,	Amherst.
Peters, Thomas H.,	North Truro.
Petersen, Anna K.,	Everett.
Petersen, Ella O.,	Everett.
Petersen, Lilian O.,	Everett.
Phelps, Annie L.,	Boston.
Potter, Sara E.,	Roxbury.
Putnam, Chas. S.,	Walpole, N. H.
Quint, Harry,	Roxbury.
Richards, J. L.,	Brookline.
Roberts, Fanny E.,	Brooklyn, N. Y.
Roberts, Jessie,	Kingston, N. Y.
Robinson, Mrs. A. M.,	South Boston.
Robinson, Dr. M. B. (Miss),	Waltham.
Roys, Mabelle F. (Mrs.),	Boxford.
Roys, Rev. Edville A.,	Boxford.
Seaverns, Annie W.,	Jamaica Plain.
Shaw, Rev. Arthur W.,	Goffstown, N. H.
Sherman, Frank M., Jr.,	West Newton.
Sherman, Sara L.,	Weston.
Sherrard, Evelyn B.,	West Waltham.
Shumway, Ruth,	Amherst.
Simmons, Alva N.,	Roslindale.
Sloane, Laura,	Amherst.
Smith, John F.,	Berea, Ky.
Souther, Marguerite,	Jamaica Plain.
Strickland, Elinor,	Amherst.
Stutson, Miss P. B.,	Columbus, O.
Sun, Y. Philander,	Worcester.
Sussman, Rudolf,	Sharon.
Story, Mrs. G. E.,	Amherst.
Tobin, Ellen C.,	Lawrence.
Tucker, Arabella H.,	Worcester.
Vining, Roscoe H.,	Ipswich.
White, Mrs. Ellen S.,	Grove Hall.
Whitman, Adelaide,	Amherst.
Whitney, Jos. T.,	Medford.
Williams, Guy F.,	North Anson, Me.
Wiswell, Ralph A.,	Newton Center.

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Public Document No. 31

TWENTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.,

BEING PART III. OF THE FIFTIETH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1913.

ENDING THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

BOSTON:
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1913.

APPROVED BY
THE STATE BOARD OF PUBLICATION.

TWENTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION.

PART I.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

INTRODUCTION.

In accordance with the provision of the act of the Legislature relative to the publication of the reports of the Massachusetts Agricultural College, the report of the experiment station, which is a department of the college, is presented in two parts. Part I. contains the formal reports of the director, treasurer and heads of departments, and papers of a technical character giving results of research work carried on in the station. This will be sent to agricultural colleges and experiment stations and to workers in these institutions as well as to libraries. Part I. will be published also in connection with the report of the Secretary of the State Board of Agriculture, and will reach the general public through that channel. Part II. will contain papers of a popular character, and will be sent to all those on our general mailing list, as well as to agricultural colleges and experiment stations, to workers in these institutions and to libraries in Massachusetts.

FRED W. MORSE,
Acting Director.

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MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-FIFTH ANNUAL REPORT

PART I.

ORGANIZATION.

Committee on Experiment Department.

CHARLES H. PRESTON, *Chairman.*
J. LEWIS ELLSWORTH.
ARTHUR G. POLLARD.
CHARLES E. WARD.
HAROLD L. FROST.

THE PRESIDENT OF THE COLLEGE, *ex officio.*
THE DIRECTOR OF THE STATION, *ex officio.*

Station Staff.

WILLIAM P. BROOKS, Ph.D., *Director.*[1]
FRED W. MORSE, M.Sc., *Acting Director.*
JOSEPH B. LINDSEY, Ph.D., *Vice-Director.*
FRED C. KENNEY, *Treasurer.*

Department of Plant and Animal Chemistry.

JOSEPH B. LINDSEY, Ph.D., *Chemist.*
EDWARD B. HOLLAND, M.Sc., *Associate Chemist, in charge of Research Division.*
FRED W. MORSE, M.Sc., *Research Chemist.*
HENRI D. HASKINS, B.Sc., *In charge of Fertilizer Section.*
PHILIP H. SMITH, M.Sc., *In charge of Feed and Dairy Section.*
LEWELL S. WALKER, B.Sc., *Assistant.*
JAMES C. REED, B.Sc., *Assistant.*
RUDOLPH W. RUPRECHT, B.Sc., *Assistant.*
GEORGE R. PIERCE, B.Sc., *Assistant.*[2]
CARLETON P. JONES, B.Sc., *Assistant.*
CARLOS L. BEALS, B.Sc., *Assistant.*
JAMES T. HOWARD, *Collector.*
HARRY J. ALLEN, *Laboratory Assistant.*
JAMES R. ALCOCK, *Assistant in Animal Nutrition.*

---

[1] On leave.
[2] Resigned.

Department of Agriculture.

WILLIAM P. BROOKS, Ph.D., *Agriculturist.*[1]
H. J. FRANKLIN, Ph.D., *In charge of Cranberry Investigations, Wareham.*
EDWIN F. GASKILL, B.Sc., *Assistant.*

Department of Horticulture.

FRANK A. WAUGH, M.Sc., *Horticulturist.*
FRED C. SEARS, M.Sc., *Pomologist.*
JACOB K. SHAW, Ph.D., *Research Assistant.*
HOWARD A. TURNER, B.Sc., *Graduate Assistant.*[2]

Department of Vegetable Physiology and Pathology.

GEORGE E. STONE, Ph.D., *Vegetable Physiologist and Pathologist.*
GEORGE H. CHAPMAN, M.Sc., *Research Assistant.*
EDWARD A. LARRABEE, B.Sc., *Assistant.*

Department of Entomology.

HENRY T. FERNALD, Ph.D., *Entomologist.*
BURTON N. GATES, Ph.D., *Apiarist.*
ARTHUR I. BOURNE, B.A., *Assistant.*

Department of Veterinary Science.

JAMES B. PAIGE, B.Sc., D.V.S., *Veterinarian.*

Department of Meteorology.

JOHN E. OSTRANDER, A.M., C.E., *Meteorologist.*
H. W. ANGIER, *Observer.*

Other Officers of the Experiment Station.

CHARLES R. GREEN, B.Agr., *Librarian.*
HERBERT J. BAKER, B.Sc., *Secretary to the Director.*[2]
BENJAMIN G. SOUTHWICK, B.Sc., *Secretary to the Director.*[2]
Mrs. LUCIA G. CHURCH, *Stenographer to the Director.*
Miss ALICE M. HOWARD, *Stenographer, Department Plant and Animal Chemistry.*
Miss F. ETHEL FELTON, *Stenographer, Department Plant and Animal Chemistry.*
Miss LINA FISHER, *Stenographer, Department Plant and Animal Chemistry.*
Miss JESSIE V. CROCKER, *Stenographer, Department of Vegetable Physiology and Pathology.*
Miss BRIDIE E. O'DONNELL, *Stenographer, Department of Entomology.*
Miss GRACE E. GALLOND, *Stenographer, Department of Agriculture.*

---

[1] On leave. [2] Resigned.

PUBLICATIONS DURING 1912.

Annual Report.

Twenty-Fourth Annual Report, Part I., 287 pages; Part II., 90 pages.

Separata from Annual Report.

Report of Entomologist, 8 pages.
Insects of the Year 1911, 4 pages.
Report of the Botanist, 108 pages.
Chemistry of Arsenical Insecticides, 36 pages.
Cranberry Substation, 12 pages.
Heredity, Correlation and Variation in Garden Peas, 22 pages.

Bulletins.

No. 140. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, J. F. Merrill and R. W. Ruprecht, 86 pages.
No. 141. The Microscopic Identification of Cattle Foods, by G. H. Chapman, 71 pages.
No. 142. Inspection of Commercial Feed Stuffs, by P. H. Smith, G. R. Pierce and R. W. Ruprecht, 48 pages.

Circulars.

No. 32. An Act to regulate the Sale of Commercial Fertilizers, 4 pages.
No. 33. An Act to regulate the Use of Utensils for testing the Composition or Value of Milk and Cream, 11 pages.
No. 34. An Act to regulate the Sale and Analysis of Food Stuffs used for Live Stock and Poultry, 7 pages.
No. 22. (Reprint) Poultry Manures, their Use and Treatment, 4 pages.
Meteorological Bulletins, 12 numbers, 4 pages each.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1912.

United States Appropriations, 1911–12.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1912, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$15,000 00
Cr.		
By salaries,	$8,908 04	$12,650 33
labor,	2,568 46	836 74
publications,	261 38	–
postage and stationery,	375 76	53 47
freight and express,	119 60	22 82
heat, light, water and power,	91 68	71 76
chemicals and laboratory supplies,	111 11	167 75
seeds, plants and sundry supplies,	661 28	223 57
fertilizers,	439 80	71 25
feeding stuffs,	689 43	–
library,	91 08	2 00
tools, machinery and appliances,	30	8 40
furniture and fixtures,	164 37	417 70
scientific apparatus and specimens,	297 90	308 68
live stock,	26 00	–
traveling expenses,	129 75	24 95
contingent expenses,	15 00	–
buildings and land,	49 06	140 58
Total,	$15,000 00	$15,000 00

State Appropriation, 1911–12.

Cash balance brought forward from last fiscal year,	$886 90	
Cash received from State Treasurer, . . .	16,875 00	
fertilizer fees, ...	10,277 00	
farm products, . . .	6,613 10	
miscellaneous sources, . .	8,143 69	
		$42,795 69

Cash paid for salaries, ...	$15,024 62	
labor, ...	8,909 03	
publications, ...	1,387 85	
postage and stationery, . .	1,004 80	
freight and express, . .	166 67	
heat, light, water and power, .	252 91	
chemicals and laboratory supplies, ...	772 41	
seeds, plants and sundry supplies, ...	1,736 42	
fertilizers, ...	504 16	
feeding stuffs, ...	1,142 96	
library, ...	260 56	
tools, machinery and appliances, ...	274 79	
furniture and fixtures, . .	316 04	
scientific apparatus and specimens, ...	378 87	
live stock, ...	5 00	
traveling expenses, . . .	2,785 85	
contingent expenses, . .	190 00	
buildings and land, . . .	895 47	
balance, ...	6,787 28	
		$42,795 69

REPORT OF THE DIRECTOR.

FRED W. MORSE, ACTING DIRECTOR.

The Agricultural Experiment Station has been unfortunate in the loss of the services of its director during the latter part of the year. Dr. Brooks was obliged to relinquish his work on account of ill health, and accept a leave of absence beginning July 1.

Vice-Director J. B. Lindsey, who acted by appointment from July 1 to October 1, found his duties as chief of the division of chemistry, in both college and experiment station, too arduous and exacting to be combined with those of the director. The trustees accordingly appointed Fred W. Morse acting director on October 1.

There have been several changes among the junior members of the station staff. Mr. Herbert J. Baker resigned his position as secretary to the director on July 1, and accepted a position with the office of farm management in the United States Department of Agriculture. He was succeeded in the experiment station by Mr. Benjamin G. Southwick, but just at the end of the year Mr. Southwick resigned to take a more responsible position in practical agriculture, and the position will remain unfilled until the return of the director.

In the department of plant and animal chemistry, Mr. George R. Pierce, Mr. Carleton P. Jones and Mr. Carlos L. Beals were appointed assistants, the first-named in the feed and dairy section and the others in the fertilizer section. Mr. Pierce resigned at the end of the year, to go to Cuba, where he is employed in a sugar-house. Miss Lina Fisher has been employed in conjunction with the college, to serve for half of the time as stenographer in the feed and dairy section.

In the horticultural department, Mr. Howard A. Turner was appointed July 1 to the position of graduate assistant in plant-breeding, but soon resigned to accept a position with the office of farm management, and the former position has remained vacant.

Miss Grace E. Gallond has been appointed stenographer in the department of agriculture and Mr. H. W. Angier has succeeded Mr. R. W. Hallowell as observer in the meteorological department. Just before the close of the year, Mr. H. D. Goodale of the Carnegie Laboratory, at Cold Spring Harbor, N. Y., was appointed research biologist in poultry-husbandry, to begin work on Feb. 1, 1913.

At the last session of the Legislature the annual appropriation for the maintenance of the experiment station was increased from $10,500 to $15,000, to become available at the beginning of the new fiscal year, Dec. 1, 1913. The trustees have assigned nearly the whole increase to the department of poultry-husbandry, and Prof. John C. Graham has been appointed head of the department, without salary from the experiment station.

The growth of the experiment station has developed a need of more land, and the trustees have deemed it the wiser policy to meet these needs by leasing satisfactory tracts in the vicinity. Two tracts have accordingly been leased, viz., a lot of twenty acres from Mrs. Mary E. Tuxbury for orchard experiments, and a tract of two acres from Mrs. Winifred Tripp for a fertilizer experiment with basic slag phosphate.

The work of the experiment station has continued without interruption along the lines described in the last annual report, and no new investigations have been undertaken; but plans have been adopted for experiments in breeding poultry with the aid of the additional State funds. The details of the progress in the different investigations will be found in succeeding pages reported by the officers who have been respectively intrusted with them.

The asparagus field at the Concord asparagus substation has produced its fourth crop this year. Mr. C. W. Prescott, in charge of the substation, reported an excellent yield amounting to a gross weight of 11,141 pounds of shoots for the whole area of two acres.

The fertilizer experiments on asparagus so far have shown positively that the use of chemical fertilizers alone has maintained the plots so treated at a somewhat higher productiveness than the combination of chemicals with stable manure. There is some indication, however, that the combined treatment will be superior in the years to come.

The three crops preceding this year showed that the maximum yield of asparagus shoots had been reached only with the maximum application of phosphoric acid. The asparagus plant is not at any stage a heavy consumer of phosphoric acid, and there had been applied a calculated surplus of the substance in the minimum amount. Nevertheless, there was evidently a need of more phosphoric acid, so the quantities applied this year were doubled and will be maintained at the higher rate in the years to come.

By another year, with the return to duty of Director Brooks, it will be possible to publish a detailed report of the fertilizer experiments.

Prof. J. B. Norton of the Bureau of Plant Industry, United States Department of Agriculture, has published the results of the experiments in breeding rust-resistant varieties of asparagus in Bulletin 263, Bureau of Plant Industry, entitled, "Methods used in breeding Asparagus for Rust Resistance." The bulletin covers the work up to the end of 1911, and shows notable progress in developing an immune variety. As a result of his field observations, Professor Norton, on page 59, makes the following important statement: "When rust was found in a commercial field, by following it up to the northwest, in the direction from which the prevailing winds come, a young bed, an old neglected bed, or wild asparagus was found in every case, and always with the remains of clustercup infections." He then suggests that wild plants should be dug up and burned, new beds should be planted where they will not affect cutting beds, and every shoot in the commercial field should be cut until the middle of June.

The cranberry substation at East Wareham has illustrated one of the uncertainties which confront the cranberry grower. The crop this year when picked was estimated to be a little over

200 barrels, while the crop of 1911 was 850 barrels. Last year's crop returned a gross income of $4,988.33; but this year's crop is not expected to return over $1,100.[1] This low yield was apparently due to a reaction or rest following the exceptionally heavy crop of 1911, because there was a relatively light bloom and no severe injury from insects or disease.

The expenditures at the substation have been grouped under three heads and do not include the salary of the superintendent. They were as follows: —

Expenses of maintenance,	$1,434 62
Permanent improvements,	551 09
Experimental,	1,243 25
Total,	$3,228 96

The work during the coming year will be somewhat curtailed to keep within the decreased income due to the scanty crop of this year. The bog is not expected to be self-sustaining as an experiment station, but as on any commercial bog the work will necessarily be contracted or expanded somewhat in proportion to the funds arising from its produce. The bog is in excellent condition and expenditures for maintenance and improvements can be lessened with no injury to it, while the experimental work can be continued without interruption.

The detailed report of Dr. H. J. Franklin for the past year will be found in another portion of this report.

The Agricultural Experiment Station has completed its thirtieth year. Its record of service can be found in the thousands of pages of its annual reports, bulletins and circulars, to which should be added the personal letters, by tens of thousands, that have been written for individual seekers after information.

During this period three decennial censuses have been taken by the State, viz., 1885, 1895 and 1905. The progress in Massachusetts agriculture shown by these censuses is interesting and indeed striking.

---

[1] The final sales in February, 1913, resulted in a return of $1,082.77 for 190 barrels of screened fruit.

Capital invested in agriculture in 1885 was $216,230,550, and in 1905 it had increased to $288,153,654, or a gain of 33 per cent. The value of agricultural products in 1885 was $47,756,000, and in 1905 it was $73,110,000, a gain of 53 per cent.

The experiment station has borne its part in this progressive agricultural movement and at slight cost to the State. Its average annual income during this period, including funds from the national treasury, has been less than one-fifth of a mill for each dollar invested in agriculture in 1885.

We believe it to be our duty at this time to point out to the people of Massachusetts new ways in which the experiment station can serve them in the years to come. Since the close of the year there have been prepared and brought together from all the departments detailed plans for projects which show new lines of investigation needed for the further advancement of agricultural interests. These projects may be grouped for convenience under the heads of crop production, crop protection, animal husbandry and agricultural economics.

Under crop production there have been proposed plans for systematic plant-breeding, which shall on the one hand determine the fundamental principles underlying the development of new varieties, and on the other hand shall result in the selection and introduction of new strains or varieties of staple farm and garden crops especially suited to our climate and soil. In fruit growing there is pointed out the need of more knowledge of cultural requirements in orcharding, owing to the differences in slope and surface of our hillsides, some of which are steep and some rolling, some rocky and some free from rocks. The adaptability of varieties needs consideration, and its study will require a knowledge of weather conditions and soil formation. A little less than one-fifth of the State has been surveyed by the Bureau of Soils of the United States Department of Agriculture, and it is desirable that this soil survey should be made complete, which must be done at the expense of the State. Judging from the surveys already made in this State and in adjacent States, there are probably between fifty and sixty distinct types of soils composing our farm lands. As specialization in crops increases, it is important that the distribution of these types be known, because it will save many would-be growers of onions, tobacco, asparagus and similar specialties from disappointment and financial loss. New crops for florists need investigation and development, and a more efficient use of fertilizers should be worked out.

Crop protection involves continual study of predaceous insects, destructive fungi and bacteria, and also diseases produced by injudicious cultural methods, particularly in the forced crops under glass. First one insect and then another upsets nature's checks and balances owing to concentration of special crops, and the same thing is true of fungous growths. Instead of new lines of investigation this field requires more workers and more facilities.

In animal husbandry, the new projects may be considered as the expansion of present lines of investigation. The poultry-breeding experiment, which has already been mentioned, is planned to include the selection of a strain of high efficiency as utility fowls, and this project will require a progressive increase of house-room and labor, as the successive generations of fowls are produced. Efficiency in feeding animals is more necessary than ever before; therefore there is positive need for more extensive work in feeding cattle, pigs, horses and poultry than the station now can perform with its facilities. Two phases of the dairy industry, which have been but little studied from a scientific standpoint, are the production of market milk and the manufacture of ice cream. These phases are peculiar to our dense city population adjacent to our farms. Diseases of our domestic animals, particularly of poultry, are becoming of increasing importance due to the enlarged amounts of capital invested in single plants, and calls for diagnosis and advice are almost incessant. The need in all these lines is for more investigators, thoroughly trained specialists, and the demand, the country over, exceeds the supply; therefore the State that bids the highest gets their services.

Economics may not seem a subject belonging to an agricultural experiment station, but certain phases have always been studied. Inspection of fertilizers and feeding stuffs may properly be included under this head, because nothing is of greater importance to the user of capital than the certainty of receiving a full return for its expenditure. There is now needed a thorough investigation of methods of seed-testing and seed-separation as a foundation for a just law controlling the sale of agricultural seeds. Equally important as economic investigations are those of ice-storage of garden vegetables and the utilization of surplus fruit and vegetables in various manufactured products with home or community facilities.

Economical use of our agricultural resources and efficient application of capital to their development require more or less study of State conditions, viz., practices of successful farmers; methods followed in milk-production, potato-growing, corn-growing, fruit-growing and so forth; relation between success and location with respect to local markets, and location with respect to transportation facilities; and the relation between social surroundings and agricultural prosperity.

In planning these projects the station workers have had in mind increasing the service of this institution in behalf of the State for the ultimate development of every farm to a higher state of productivity and the assurance to the farmer of a greater prosperity.

To execute these projects will require double the present income of the experiment station, but the experiment station neither begs nor demands that this income be given it. It has presented the subject to the people and is ready to serve them, and will serve them to the utmost of its facilities.

DEPARTMENT OF AGRICULTURE.

REPORT OF THE AGRICULTURIST.

E. F. GASKILL, ASSISTANT.

The duty of preparing the annual report of the agricultural department has fallen to the assistant agriculturist. Dr. Wm. P. Brooks, who has served as agriculturist of the experiment station since 1889, was forced to give up his duties last June because of ill health, and by vote of the trustees has been given leave of absence until September, 1913.

The work of the department for the past year was outlined almost entirely by Dr. Brooks and has followed the same general lines as in previous years, namely, experiments with fertilizers involving the use of 181 field plots, 13 orchard plots, 132 pots in our vegetation work and 147 inclosed plots, used largely to check results obtained in the field.

From year to year the department has made a careful study of many of the more promising varieties of potatoes, corn and soy beans; has investigated the possibilities of growing alfalfa in the State; and has co-operated with other departments of the station in carrying out many lines of investigation; but the main question under consideration has been the study of problems connected with soil fertility. Preferring to base conclusions on averages for a number of years, rather than on the results for one or two years, many of the fertilizer experiments have been continued from year to year. In view of this fact the report of the experimental work in this department, as in previous years, must in most instances be a report of progress. It is intended to present the work according to the plan generally followed, in order that the successive reports may furnish a complete record of each experiment.

THE COMPARISON OF DIFFERENT MATERIALS AS A SOURCE OF NITROGEN.

Field A.

In this experiment there are eleven plots of one-tenth acre each, separated by division strips 4 feet in width. They have been fertilized each year according to the following plan: [1] —

PLOT.	Source of Nitrogen.	Source of Potash.	Source of Phosphoric Acid.
0	Barnyard manure, [2] . .	- -	- -
1	Nitrate of soda, . .	Muriate of potash, . . .	Dissolved bone-black.
2	Nitrate of soda, . .	Sulfate of potash-magnesia, .	Dissolved bone-black.
3	Dried blood, . . .	Muriate of potash, . . .	Dissolved bone-black.
4	Nothing, ...	Sulfate of potash-magnesia, .	Dissolved bone-black.
5	Sulfate of ammonia, . .	Sulfate of potash-magnesia, .	Dissolved bone-black.
6	Sulfate of ammonia, . .	Muriate of potash, . . .	Dissolved bone-black.
7	Nothing, ...	Muriate of potash, . . .	Dissolved bone-black.
8	Sulfate of ammonia, . .	Muriate of potash, . . .	Dissolved bone-black.
9	Nothing, ...	Muriate of potash, . . .	Dissolved bone-black.
10	Dried blood, . . .	Sulfate of potash-magnesia, .	Dissolved bone-black.

The nitrogen, phosphoric acid and potash are applied in equal amounts to all plots except 4, 7 and 9. These receive phosphoric acid and potash but no nitrogen.

During the twenty-three years of the experiment the crops grown have been: 1890, oats; 1891, rye; 1892, soy beans; 1893, oats; 1894, soy beans; 1895, oats; 1896, soy beans; 1897, oats; 1898, oats; 1899, clover; 1900, potatoes; 1901, soy beans; 1902, potatoes; 1903, soy beans; 1904, potatoes; 1905, oats and peas; 1906, corn; 1907, clover; 1908, clover; 1909, clover;

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[1] The materials are used at the following rates per acre: —

	Pounds.
Nitrate of soda,	290
Sulfate of ammonia,	225
Dried blood,	525
Muriate of potash,	250
Sulfate of potash,	485
Dissolved bone-black,	500
Manure,	8,000

[2] In addition, nitrate of soda, dissolved bone-black and sulfate of potash-magnesia have been applied to equalize the nitrogen, phosphoric acid and potash on plots 1-10.

1910, clover; 1911, corn followed by clover; and 1912, corn followed by clover.

The variety of corn grown this year was the same as last, — Rustler White Dent. It made a very satisfactory growth and was well matured by the 19th of September, on which date it was cut and stooked. The average yields for this year are shown in the following table: —

Average Yields per Acre, 1912.

Plot.	Hard Corn, Ears (Bushels).	Soft Corn, Ears (Bushels).	Stover (Pounds).
No-nitrogen (4, 7, 9),	67.86	1.61	5,116.70
Nitrate of soda (1, 2),	93.00	1.79	5,700.00
Dried blood (3, 10),	89.57	1.31	5,450.00
Sulfate of ammonia (5, 6, 8),	78.26	1.62	5,133.30
Manure (0),	80.00	1.29	5,000.00

On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen plots and no-nitrogen plots, as measured by total yield during the past season, was as follows: —

	Per Cent.	
	Grain on Cob.	Stover.
Nitrate of soda,	100.00	100.00
Barnyard manure,	94.62	87.72
Dried blood,	96.31	95.61
Sulfate of ammonia,	84.15	90.06
No-nitrogen,	72.97	89.77

The relative standing of the different materials as indicated by total yield for the twenty-three years during which the experiment has continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.28
Dried blood,	92.95
Sulfate of ammonia,	87.38
No-nitrogen,	73.04

On the basis of increase as compared with the no-nitrogen plots the relative standing for the different fertilizers for the twenty-three years is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	78.78
Dried blood,	73.85
Sulfate of ammonia,	53.19

Nitrate of soda, as in previous years, shows the greatest average increase. The striking results obtained last year on the no-nitrogen plots are not so apparent this year. In 1911 the yield on the no-nitrogen plots was 95 per cent. of the average yield on all the different nitrogen plots; this year the no-nitrogen plots are represented by 73 per cent. In commenting upon the good showing made by the no-nitrogen plots last year, Dr. Brooks said: —

> One of the most striking results of the past season was the relatively large yield produced on the no-nitrogen plots. It amounts to about 95 per cent. of the average yield on all the different plots which have received an application of nitrogen annually. This result, it will be readily understood, was no doubt due to the fact that clover for three years had preceded the corn crop of the past year. The figures emphasize in a most striking way the extent to which rotations including a legume may be made to take the place of the use of nitrogen fertilizers.

MURIATE *v.* SULFATE OF POTASH.

Field B.

This is the twenty-first year of the experiment. The field consists of five pairs of plots, numbered from eleven to twenty. The odd plots (eleven, thirteen, etc.) have received annually an application of muriate of potash, while the even plots (twelve, fourteen, etc.) have received an application of high-grade sulfate of potash. In addition to the potash the plots have received annually an application of bone meal at the rate of 600 pounds per acre. During the early period of the experiment the potash salts were used in different amounts in different years. For the last twelve years an annual application of

250 pounds per acre has been applied to each plot. The object has been to supply annually the same amount of actual potash to each plot, and to study the effects of the continued use of these potash salts upon the same soil. The following table shows the crops grown this year and the rate of yield per acre for each: —

	Alfalfa (Pounds).	Asparagus (Pounds).	Blackberries (Pounds).	Rhubarb.		Raspberries (Pounds).	Strawberries (Pounds).	Mangel-wurzels.	
				Stalks (Pounds).	Leaves (Pounds).			Roots (Pounds).	Tops (Pounds).
Muriate of potash,	5,837	5,734	4,027	17,647	19,669	939	4,403	40,608	6,486
Sulfate of potash,	7,331	4,348	4,609	25,343	28,302	1,300	5,087	32,897	4,276

Comparison of Different Potash Salts for Field Crops.

Field G.

The plan and object of this experiment is quoted from the nineteenth annual report of the experiment station: —

> This experiment is designed to show the ultimate effect upon the soil, as well as the current effect upon the crops, of continuous use of different potash salts. We have under comparison kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate.[1] The field includes forty plots, in five series of eight plots each. Each series includes a no-potash plot, as well as the seven potash plots which have been named. The experiment is therefore carried out each year in quintuplicate. The area of each plot is one-fortieth of an acre. The potash salts under comparison are used in quantities which will supply annually actual potash at the rate of 165 pounds per acre to each of the plots. All plots are equally manured, and liberally, with materials furnishing nitrogen and phosphoric acid.[2]

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[1] Owing to our inability to obtain silicate of potash feldspar was substituted in 1908, and has since been used on these plots.

[2] The nitrogen and phosphoric acid are supplied by the following materials per acre: —

	Pounds.
Nitrate of soda,	250
Tankage,	270
Acid phosphate,	360

The crops grown on the field this year were as follows: —

Series I., plots 1–8, Rustler White Dent corn.
Series II., plots 9–16, Medium Yellow soy beans.
Series III., plots 17–24, Danish Ballhead cabbage.
Series IV., plots 25–32, Golden Tankard mangel-wurzels.
Series V., plots 33–40, Sweet German turnips.

The relative standing of the different potash salts for this year is shown in the following table: —

Yields per Acre.

POTASH SALT.	SERIES I.			SERIES II.		SERIES III.	SERIES IV.		SERIES V.	
	CORN.			SOY BEANS.			MANGEL-WURZELS.		TURNIPS.	
	Hard Ears (Bushels).	Soft Ears (Bushels).	Stover (Pounds).	Beans (Bushels).	Straw (Pounds).	Cabbage (Pounds).	Roots (Pounds).	Tops (Pounds).	Roots (Pounds).	Tops (Pounds).
No potash,	75.43	–	4,200	24.48	2,920	37,800	31,880	13,720	27,000	13,600
Kainit,	83.43	–	5,600	24.14	2,800	41,000	36,880	16,120	38,520	12,880
High-grade sulfate,	81.14	–	5,280	27.59	3,320	41,400	32,400	12,200	37,120	12,280
Low-grade sulfate,	84.00	–	5,200	28.97	3,520	44,000	38,800	15,200	38,000	11,400
Muriate,	82.86	–	5,400	27.59	3,360	46,880	35,600	14,800	37,400	12,200
Nitrate,	80.57	.57	5,400	28.28	3,500	50,200	28,800	10,200	34,120	10,080
Carbonate,	47.43	1.14	5,480	19.31	2,420	47,400	37,000	12,000	33,400	11,200
Feldspar,	80.57	–	4,200	22.76	2,840	30,600	31,600	13,000	29,800	12,800

Comparison of Different Phosphates.

This is the sixteenth year of the experiment, the plan and object of which is quoted from the twenty-third annual report: —

> Ten of the leading materials which may be used as a source of phosphoric acid have been under comparison in one of our fields since 1897. The different materials are applied to the separate plots in such quantities as to furnish equal amounts of actual phosphoric acid to each. There are three check plots to which no phosphate whatever has been applied during the entire period of the experiment. All the plots receive annually equal and liberal quantities of materials supplying nitrogen and potash in highly available forms. The field has been used for a large variety of crops, the succession having been as follows: corn, cabbages, corn, oats and Hungarian grass (followed by rye plowed under), onions, onions, corn, mixed grass and clover three years, cabbages and soy beans and potatoes.

In view of the fact that the results of similar experiments (comparison of different materials as sources of phosphoric acid) in other States have not shown the marked differences between the ground rock phosphates and the more soluble phosphates that our results show, and in view of the fact that the humus content of the different soils is claimed by some authorities to be the cause of the differences in the showing of the rock phosphates, it has been our aim in the treatment of the field for the last few years to get as much humus into the soil as possible.

In 1911 the field was seeded in May with oats and alfalfa. Two crops were harvested, one in July and one in September. In 1912 the field was plowed and Japanese Buckwheat sown, which was plowed under in July. In August rye was sown, to be plowed under in the spring.

AVERAGE CORN FERTILIZER COMPARED WITH FERTILIZER RICHER IN POTASH.

North Corn Acre.

The two systems of fertilizing have been under comparison for twenty-two years. The object has been to determine whether or not the average corn fertilizer sold on our markets contains the right proportions of nitrogen, phosphoric acid and potash. The field consists of four plots of one-fourth acre each. Two of the plots — 1 and 3 — receive annually an application of a home-made mixture furnishing the different plant-food elements in the same proportions as in average corn fertilizer. The other two plots receive an application of a home-made mixture furnishing less phosphoric acid and more potash than the average corn fertilizer. The rotation is two years of grass and two years of corn. The crop this year was corn. The following table shows the relative standing of the two mixtures for this year: —

	CORN ON THE COB.		Stover (Pounds).
	Hard Ears (Bushels).	Soft Ears (Bushels).	
Average corn fertilizer,	55.66	1.26	3,566
Fertilizer richer in potash,	61.69	1.37	4,090

The different materials were used on the plots at the following rates per acre: —

FERTILIZERS.	Plot 1 (Pounds).	Plot 2 (Pounds).	Plot 3 (Pounds).	Plot 4 (Pounds).
Nitrate of soda,	120	200	120	200
Dried blood,	120	–	120	–
Fish,	150	200	150	200
Acid phosphate,	1,092	200	1,092	200
Muriate of potash,	150	250	150	250
Slag,	–	–	–	400

The amount of plant food furnished an acre, its cost, and the profit realized by using the different mixtures are shown in the following table: —

PLOTS.	Amount (Pounds).	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).	Cost.[1]	Grain (Bushels).[2]	Stover (Pounds).	Value.[3]	Profit.[4]	Formula.
1 and 3, . .	1,632	38.35	196.49	77.68	$17 90	55.66	3,566	$44 97	$27 07	2.35–12.04–4.76
2 and 4, . .	1,050	42.93	104.01	129.63	15 41	61.69	4,090	50 34	34 93	4.09–9.91–12.34
Average corn fertilizer.[5]	1,700	41.65	165.07	76.84	28 27	–	–	–	–	– –

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[1] Represents the actual cost of chemicals. To these should be added the cost of mixing, which will range from $1.50 to $2 per ton.

[2] The late spring and the unusually dry summer were not favorable for a good corn crop. In 1911 on these same plots the average yield of the four plots was over 85 bushels per acre.

[3] Based on the value of the crop at harvest time.

[4] Represents the difference between the cost of chemicals and the value of the crop. The labor question was not considered in this comparison because it was the same for all plots.

[5] The prices and formula for the corn fertilizer were obtained by taking an average of all the corn fertilizers reported in the 1911 fertilizer bulletin.

The composition of the corn fertilizers varies widely, and in taking an average of all corn fertilizers, reported in our fertilizer bulletin from year to year, we find considerable variation. The percentage of phosphoric acid is not as high at the present time as in former years.

The tables show that in order to supply about the same amounts of plant food per acre, it would be necessary to use 1,700 pounds of the average corn fertilizer. This at the average price per ton would cost over $28. It will be seen from the figures representing the cost of the different chemical mixtures, and the crops obtained, that it would be necessary to harvest a much larger crop on this fertilizer in order to insure a profit as large as that shown for the other fertilizers.

The prices used in these calculations were as follows: corn on the cob, 60 cents per bushel; stover in the field, $6.50 per ton; fertilizers at the current prices for 1912.

MANURE ALONE COMPARED WITH MANURE AND SULFATE OF POTASH.

South Corn Acre.

The two systems of manuring have been under comparison for twenty-two years. The field consists of four plots of one-fourth acre each. Two of the plots — 1 and 3 — receive an application of barnyard manure at the rate of 6 cords per acre, while the other two receive an application of manure at the rate of 4 cords per acre, and in addition an application of high-grade sulfate of potash at the rate of 160 pounds per acre. The crop grown this year was corn. The relative standing of the two systems for this year is shown in the following table: —

	Corn on the Cob.		Stover (Pounds).
	Hard Ears (Bushels).	Soft Ears (Bushels).	
Manure alone, ...	67.57	1.43	4,460
Manure and potash, ...	63.34	1.86	3,840

The following table gives the amount of fertilizer used per acre on each plot, its cost and the profit: —

Plot.	Fertilizer.	Cost.[1]	Grain (Bushels).[2]	Stover (Pounds).	Value.[3]	Profit.[4]
1, . .	6 cords manure, . .	$30 00	71.71	4,360	$57 20	$27 20
3, . .	6 cords manure, . .	30 00	63.43	4,560	52 88	22 72
2, . .	4 cords manure and 160 pounds high-grade sulfate.	24 00	60 00	3,800	48 35	24 35
4, . .	4 cords manure and 160 pounds high-grade sulfate.	24 00	66.63	3,880	52 59	28 59
1 and 3, .	Average, ...	30 00	67.57	4,460	55 04	25 04
2 and 4, .	Average, ...	24 00	63.34	3,840	50 48	26 48

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[1] Represents the actual cost of the fertilizer used.

[2] The late spring and the unusually dry summer were not favorable for a good corn crop. In 1911 on these same plots the average yield of the four plots was over 86 bushels per acre.

[3] Based on the value of the crop at harvest time.

[4] Represents the difference between the cost of the material used and the value of the crop. The cost of spreading the manure was not considered because this item of expense would not be the same in very many cases.

Comparing the average of plots 1 and 3 with the average of plots 2 and 4 we find the materials cost more for 1 and 3; the amount of grain and stover produced is larger, but the profit is less.

The difference in favor of using the smaller amount of manure and potash is still more apparent when we consider that we have two cords less of manure to handle.

Comparison of Winter and Spring Application of Manure.

The details of the plan and object of this experiment may be found in the nineteenth annual report: —

> This experiment was planned to be continued through a series of years, with a view to throwing light upon the question as to the best method of handling farm manures. The field in use has an area of a little less than three acres, and slopes moderately to the west. It had been divided into five plots a number of years previous to the beginning of this experiment, for the comparison of different fertilizers. Each of these five plots was subdivided into two sub-plots. To one of the sub-plots in each of the five pairs the manure is applied during the winter, being spread upon the surface as it is hauled to the field; to the other sub-plot in each of the five pairs the manure as it is hauled is put into a large, compact heap. The manure used is carefully preserved, from well-fed dairy cows on four of the pairs of plots (1, 2, 3 and 4), and purchased stable manure from horses on one pair of plots (5). The experiment is so managed that all the manure is hauled for a single pair of plots at one time, usually during a single day, or at most within two days. To insure even quality of the manure on the two sub-plots, loads are placed alternately on the north half, where it is spread as hauled; and on the south half, where, as has been stated, it is put into a large heap. The land has usually been plowed late in the fall. The manure has usually been applied to the two sub-plots 1 early in the winter; to the sub-plots 2, 3 and 4, respectively, at intervals each about one month later than the preceding. The manure which is placed in the heaps remains there until it is time to prepare the soil for planting in the spring. It is then spread, and as soon as convenient the entire area, including both the winter and spring applications, is plowed.

Manure was omitted in 1912 and will not be applied as in previous years. Records will, however, be kept, the object now being to test the residual effect of the two systems of applying manure. There are five pairs of plots in the experiment. The crop this year was mixed grass and clover hay. The average yields per acre in 1912 were: —

	Hay (Pounds).	Rowen (Pounds).
Winter application,	5,528.4	364.0
Spring application,	5,745.8	795.4

TOP-DRESSING PERMANENT MOWINGS.

An outline of the plan and object of this experiment is quoted from the sixteenth annual report: —

> In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot, one year barnyard manure, the next year wood ashes, and the third year fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

The past year brought the fifth successive season unfavorable to hay production. The rain fall in May was slightly above the normal, but the following month was one of the driest Junes recorded since records have been kept here at the college.

The yield obtained this year on the different systems of manuring is shown in the following table: —

FERTILIZERS USED.	YIELD PER ACRE.		
	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	3,610	1,359	4,969
Bone and potash,	3,655	1,164	4,819
Wood ashes,[1]	3,171	1,616	4,787

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[1] Owing to the difficulty of securing good wood ashes a mixture of slag and muriate of potash, supplying the same amount of phosphoric acid and potash, was substituted this year.

The average yield for the entire period of the experiment (1893–1912, inclusive) for each system of manuring is shown in the following table: —

	Pounds.
Barnyard manure,	6,149
Bone and potash,	5,999
Wood ashes,[1]	5,636

The average yield for the entire area this year was 4,846 pounds, — a little better than the average yield for last year, but not equal to the average yield for the entire period of the experiment (1893–1912, inclusive) which is 5,959 pounds. The average yield for the period 1893–1911, inclusive, was 6,018 pounds.

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[1] Owing to the difficulty of securing good wood ashes a mixture of slag and muriate of potash, supplying the same amount of phosphoric acid and potash, was substituted this year.

DEPARTMENT OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

REPORT OF THE BOTANIST.

G. E. STONE.

This department has the past year been engaged in the usual routine and research work, investigations being made of the new diseases which come to our attention and which are given a thorough study if they prove serious.

Mr. G. H. Chapman, research assistant, has been engaged on problems of a technical nature, and Mr. E. A. Larrabee's attention has been given mainly to the diagnosis of diseases and seed work. The office work has been carried on as usual by Miss J. V. Crocker, and Mr. R. G. Smith, who is at present assisting in the senior laboratory, performed some experiments in the summer with the chestnut bark disease. Messrs. Torrey, Larsen, Ellis, Lyon, Sullivan and Chase, undergraduate students, have given assistance in various ways, — in the greenhouse, with experiments, etc., and Mr. T. W. Nicolet has taken many of the photographs. A list of several problems which the department has been investigating follows.

A careful study is being made of some of the diseases of field and greenhouse crops. This includes an investigation of the conditions causing the diseases and experiments with methods for their control. Among those receiving special attention are some diseases of the apple, potato, cucumber, melon, lettuce, tomato and herbaceous plants and shade trees. In the last two years there has been present a serious blight on greenhouse cucumbers which has in some instances caused a total failure of the cucumber crop in this section, and some study has been made of this disease. For five years experiments have been carried on relative to the control of potato scab, and some of the results of this work will be contained in this report. These experiments will be continued.

Some further lines of work are given in brief: —

Investigations relating to improved methods of seed germination and separation.

Experiments on the control of weeds in lawns, etc.

Investigations relating to the injurious effects of oil sprays on fruit trees.

Investigations relating to the effects on shade trees of chemical substances applied to roadbeds.

Investigations relating to the effects of different fumigants on greenhouse crops which are subject to variations in light intensity and moisture.

Investigations relating to the effects of various spraying solutions on plants exposed to variations in light intensity, etc.

Investigations relating to the burning of the foliage of greenhouse plants by fumigants as related to the condition of the stomata.

A study of the weed situation in cranberry bogs.

Testing of a large variety of chemical substances to ascertain their fungicidal value.

Investigations relating to overfeeding and malnutrition in greenhouse plants, a trouble which is becoming more common in greenhouses.

Investigations relating to the relationship between various light intensities and the effects of different spraying solutions, and the maximum carbon assimilation in such crops as potatoes, grapes, etc.

Investigations relating to the fixation of nitrogen by the electrical stimulation of micro-organisms.

Experiments with methods of keeping roots from drain tiles, — a continuation of those already published.

A study of spraying machinery and new types of nozzles.

Experiments with a new type of soil sterilizer.

Investigations relating to the mosaic disease as occurring on different plants; nearly completed.

Investigations relating to light in greenhouses; practically completed.

Experiments with methods of treating tree cavities.

Experiments with the effects of varying percentages of soil, moisture and air on the germination of seeds.

Experiments with the effects of ozone on seed germination and various plant activities.

These investigations have been carried on in some cases for some time, and several of them would properly come under the heading, "Investigations of the effects of meteorological conditions on the diseases and the development of plants in general," which we are studying under the "Adams fund."

DISEASES MORE OR LESS COMMON DURING THE YEAR.

G. E. STONE.

Like the year before, this season has been characterized by severe drought in the summer months, with some rain in the fall, although the rainfall in August, September and October was less than the normal. In November, however, it exceeded the normal. In May, June and July the drought and heat were such as to cause considerable defoliation of trees and unevenness in corn fields, although this last was in some cases due to poor seed which was affected by frost the year before.

The unusually large onion crop ripened poorly in some fields, and in the Connecticut valley many hundreds of bushels had to be left on the ground owing to non-maturity. Potatoes were of excellent quality, with less than the usual amount of early blight, and the rot was not very noticeable. Apple trees showed some winter killing of the twigs and roots as the result of the preceding severe winter, with some sunscald and a few cases of what appears to be injury from spraying with oil. The leaves of those trees in particular which were not sprayed were affected to an unusual degree with scab (*Fusicladium*) and leaf spots (*Sphæropsis*). The scab was more or less common on the fruit in the fall and was accompanied in almost every case by pink mold (*Cephalothecium*), but no serious injury occurred. Apple rust (*Gymnosporangium*), which has been more or less common the last three or four years, was seen occasionally on the leaves, and in a few instances affected the fruit. Storage burns were common in some localities, due possibly to defective storage conditions, and in other cases to the rather poor ripening or hardening up of the fruit. Apple fruit rots were unusually abundant late in the fall, being caused, apparently, by the abnormal ripening of the fruit. As usual, there was very little rot (*Glœospo-*

rium) on the tree, but it occurred later at the time of harvesting. The black rot (*Sphæropsis*) usually constitutes 80 or 90 per cent. of our fruit rots, but this year the bitter rot (*Glœosporium*) prevailed and *Sphæropsis* was quite scarce, and for this reason there was more rotting of the fruit on the tree than is usually seen here. The brown rot (*Sclerotinia*) and blue mold rot (*Pencillium*) were quite common, as was the fruit spot (*Cylindrosporium*), which affected many varieties of apples.

Crown gall (*Pseudomonas*) is not so prevalent now as a few years ago, as greater care is being taken in buying apple stock. Peach leaf-curl (*Exoascus*) was unusually severe in the spring, especially on unsprayed trees, and much curling of the foliage was caused by aphis. Peach and plum rots (*Sclerotinia*) were not common, and other than the winter killing of the fruit buds the trees made good growth and were quite free from disease. There was some pear blight (*Bacillus*) and sooty mold, which grows in the secretions of aphis. Rusts (*Gymnosporangium*) in general have been more common the past four years, but they were less conspicuous this season than last. Among these may be mentioned quince, bean, apple, Vinca, rose and ash rust. The quince rust continues to be more or less of a pest. The white pine blister rust (*Cronartium*), introduced a few years ago, is now receiving attention from the nursery inspector. The European currant rust, one stage of the pine blister rust, has recently made its appearance, being first observed on the black currant in Essex County, the only location known in this State at the present time.

Among other more or less common diseases noticed during the year are the maple leaf spot (*Rhytisma*), pea mildew (*Erysiphe*), several sweet pea troubles of a miscellaneous character, the leaf spot of the cherry (*Cylindrosporium*), asparagus rust (*Puccinia*), oat smut (*Ustilago*), hollyhock rust (*Puccinia*), potato scab (*Oospora*), corn smut (*Ustilago*), black rot of grape (*Guignardia*), bacterial wilt of cucumbers (*Bacillus*), currant leaf spot (*Septoria*), frost injury to asparagus, blossom end rot of tomatoes and scab (*Cylindrosporium*), oak and sycamore leaf blight (*Glœosporium*), black spot of rose (*Actinonema*), rose mildew (*Sphærotheca*), leaf spot of mignonette (*Cercospora*), melon blight (*Alternaria*), celery blight (*Cercospora*), apple canker (*Sphæropsis* and *Nectria*), and winter killing of raspberries and roses, sycamore twigs, privet and others.

The unusually severe infection from aphis caused a loss of foliage to many trees. A peculiar mottling of chestnut leaves which were thickly covered with honey-dew was noticed, and examinations of the leaf tissue revealed a partial plasmolysis of the cells, accompanied by considerable defoliation; but after showers, which would wash off the honey-dew, the defoliation would cease.

The general deterioration of shade trees which has been noticeable for the last six or seven years has been even more pronounced the last two years. The trees showing the most deterioration are the elm, maple, white and black ash, butternut and Norway spruce; and the sycamore showed winter killing of the twigs last season, with a Glœosporium infection of the foliage. The roots of the elm, maple and oak are constantly dying back, and for the last two years maples have been showing what is termed "staghead," supposed to be due to a diminution of water in the soil in some cases, and in others winter killing of the roots is no doubt a contributing factor. Many thousands of maples have been so affected in the northeastern United States. Last winter was one of the worst on record for depth of freezing, and vegetation in general was in poor condition, owing to the drought, to enter upon even a mild winter. The freezing of gas and water pipes was of so frequent occurrence as to cause an unprecedented number of leaks. In one city with about 50 miles of pipes, over 200 leaks were recorded, the loss of gas amounting to about 33 per cent., and in some cases sections of the supply had to be cut off. Thus it is not surprising that winter injury of various kinds occurred, although to what extent vegetation has suffered we cannot tell as yet.

A NEW RUST.

G. E. STONE.

Currant Rust, White Pine Blister Rust.

In previous reports we have mentioned an epidemic of rusts which have been unusually severe the past few years on the apple, bean, quince and ash, and last year we noted a new rust on Vinca. A new form has lately made its appearance on the black currant. The white pine blister rust has also been with us for several years, affecting most largely young nursery stock, although it is occasionally found on white pines of fairly good size. On September 28 some specimens of currant rust were sent in from a large estate in Essex County, this being the first outbreak recorded in Massachusetts to our knowledge. At practically the same time Dr. G. P. Clinton observed a similar outbreak in Connecticut, and Prof. F. C. Stewart, of the Geneva Experiment Station, noted an outbreak in New York.

The rust in this State is confined, so far as we know at the present time, to one block of 200 currant plants of the Black Champion variety. The plants were two-year-olds, purchased last spring from a New York nursery, and practically all in this block were infested except about twenty-five or thirty in the southwestern corner of the block. About a quarter of a mile south of the diseased currants was a small block of old black currants, but they showed no signs of Cronartium. About the same distance east was a magnificent stand of eight-year-old pines, but rigid examination failed to reveal any signs of blister rust infection; neither was any infection found on the near-by block of red currants.

The following description of the currant rust and white pine blister rust, which are different stages of the same rust, was prepared at my request by Mr. E. A. Larrabee, from various literature.

The white pine (*Pinus Strobus*) blister rust (*Peridermium Strobi*) has only been known in Germany for the last thirty or forty years. In this country it has been discovered within the last few years. In 1906 Dr. F. C. Stewart of the Geneva station in New York found the disease on the grounds there, but prompt and radical treatment is believed to have completely eradicated it. Again, in 1909, it was found in New York State on a shipment of three-year-old white pine seedlings from Germany.

This fungus has two well-known forms which have in former years been described as two distinct species, — one appearing on the currant and gooseberry (*Ribes*), and the other on the white pine. The stage found on the Ribes bushes was discovered and named about fifty years ago by Dietrich, while the stage on the pine was discovered and named by Klebahn in 1887. Since this time, however, by careful and extensive inoculation experiments, it has been conclusively proved that *Peridermium Strobi* on the pine, and *Cronartium ribicola* on Ribes are not two distinct species of fungi, but are different stages of the same organism.

Unfortunately, the presence of this fungus is not apparent at or before planting time. It is particularly noticeable in this country probably during the month of May. It then covers the trunks of young pines of four or five years and over, as well as the trunks and branches of older pine trees, with bright yellow blisters in which are contained the æcidiospores. These æcidiospores appear as a dark yellow powder and cannot germinate unless they fall on the leaves of currants or gooseberries (*Ribes*). On these leaves, however, they develop, send germ tubes into the leaf tissue, and there form a heavy matting of mycelium. Along about the middle of June there are formed on the under side of the leaves of these Ribes plants bright yellow deposits (uredospores) which spread the disease from leaf to leaf on these plants. These uredospores continue to spread throughout the Ribes during the entire season in which young leaves are formed. In the summer, too, still another reproduction cell is found in the shape of yellow-brown strings or sacs, of about the thickness of a hair, on the under side of the leaves of the Ribes bushes, and these are known as teleutospores. On the surface of these so-called strings are deposited tiny cells known as sporidia. These sporidia will germinate only on the bark of young shoots of the white pine.

The so-called sporidia are produced and carried about by the wind at the very season when the young pine shoots have begun to develop and are in a condition to be readily infected. When the small sporidia germinate they send their germ tubes into the tender bark of the white pine, and there the mycelium again forms a heavy matting. This tissue lives for many years in the branches, and occasions considerable swelling of the shoots, by which the disease may be detected in the fall and winter, when there are no yellow deposits on the bark. These swellings often do not show on the white pine for perhaps a year or more. It is probably several years after infection before these dark yellow spore blisters are formed, but when they once appear they often reappear every spring for a number of years on the same swellings. Their appearance is preceded by the formation of very small dot-like heaps of spores which are called spermogonia. These spermogonia contain sweet-tasting, sticky spores, so-called spermatia, about which nothing is known.

It will be seen from the preceding that this disease cannot spread from one pine to another. It must first go from pine to Ribes (in May or June) and from Ribes back to pine (in August or September). In the trunks of pine trees the fungus is perennial, but on Ribes it affects only the leaves and cannot live over winter.

While it would appear from this description of the rust that an alternation of hosts is necessary in the case of currant rust, some American pathologists would question this, and observations made by some investigators on the rust in this country seem to indicate that the rust may be able to propagate indefinitely on the currant without the intervention of the pine.

At the request of Professor Stewart we are therefore conducting experiments to determine whether reinfection of currants can occur without the intervention of the pine. These are now being carried on in our greenhouse, together with some other experiments relating to the control of the disease; and work along the same lines is being done by Dr. Clinton in Connecticut.

This disease on the currant can undoubtedly be eradicated by some method of spraying, but if not, it may be necessary to destroy all the black currants in the State, as they are not of great economic importance. The white pine blister rust is being carefully looked after by Dr. H. T. Fernald, State Inspector of Nurseries.

EFFECTS OF ILLUMINATING GAS ON VEGETATION.

G. E. STONE.

It is well known that escaping illuminating gas in the soil has an injurious effect on vegetation, and occasionally kills trees. In States where records[1] are required of the amount of gas manufactured, and that unaccounted for, the loss is found to amount to considerable in some cases, but this does not always mean that all unaccounted-for gas escapes in the soil or air, since these measurements are dependent on different meter readings. The meters may run too slow or too fast, requiring a great deal of care to warrant any degree of accuracy. Moreover, gas varies greatly with temperature, and even 6 or 8 per cent. of unaccounted-for gas is not necessarily all leakage.

There are several kinds of gas used for lighting and heating, *i.e.,* water gas, coal gas, gasoline gas, acetylene gas and others, but their effects on the plant are quite similar, and they are all very poisonous to vegetation. Even the same kind of gas varies to quite an extent, as the process of manufacture is not always the same. This difference in composition is often very slight, but to any one who has had experience in diagnosing trees killed by gas it is discernible; for example, the gas manufactured by one corporation will produce different effects on a tree from that manufactured by another; yet gas from the same plant differs very little as a rule.

Illuminating gas is very poisonous to vegetation. The poisonous properties are largely confined to the numerous products which are absorbed by the soil moisture in small quantities, taken up by the roots and translocated through the tissue.

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[1] Consult Ann. Repts. of Inspector of Gas Meters and Illuminating Gas, Mass. Public Documents, No. 55; Ann. Repts. of Board of Gas and Elec. Light Comm., Mass. Pub. Documents, No. 35.

These substances are to be found in the tissue, although, as already pointed out, the reactions are not quite the same in different places nor on different species of trees. Trees poisoned by illuminating gas usually show some characteristic post-mortem symptoms, but many of these symptoms may be found in trees dying from other causes. More or less rapid deterioration and increased brittleness of the wood is a quite characteristic symptom, however.

In summer the first effects of gas poisoning may be seen in the foliage. The leaves turn yellow and in some cases drop off, while the leaves of other trees fall while still remaining green, and in still other cases the trees do not become defoliated but the leaves turn a reddish brown and die. The upper part of the tree, being far away from the source of water supply, usually shows the effects first. All this occurs before there is any evidence of abnormal tissue above ground. The water contents of the soil containing the poisonous principles of gas pass up through the roots and stems, and later the wood and zone constituting the living portion of the trunk become abnormal. The first symptoms appear in the characteristic dryness of the cambium and other tissues outside the wood, this being the first indication of the approaching death of the tissue. Later these tissues, — cambium, phloem and cortex, — turn brown and disintegration follows. These abnormal conditions first take place in the roots, which are the first to absorb the poison, but later, as absorption and translocation proceed, the poisonous constituents may be detected in the wood, etc., at the base of the tree. It not infrequently happens that the tissue at the base of the tree is dead, while that in the trunk a few feet above is alive. But this condition does not endure, for sooner or later the whole tree becomes involved. When the underlying tissues, cortex, phloem, etc., die, the bark changes color, gradually growing darker, the tissue tensions are destroyed, and the physical properties of the bark are greatly changed. Soon various species of fungi, such as *Polystictus*, *Schizophyllum* and others, find a foothold on the bark and borers and other insects attack the dead tissue. Even bacteria and molds, like *Penicillium,* become active and hasten the process of disintegration, the smaller twigs becoming dry and brittle, and the ends are often broken off. The upper limbs usually lose their bark first, and eventually the larger limbs present the same appearance. Disintegration may become so rapid that in one and a half to three years most of the larger branches will break off, and soon nothing but a portion of the trunk and a few stubs remain.

All these conditions refer merely to the way in which a tree succumbs to gas poisoning, and do not necessarily constitute reliable symptoms of this type of injury, as these symptoms may be found in trees dying from other causes. The tissue furnishes the most reliable symptoms for diagnosis. The writer has for years been examining thousands of trees killed by gas, and has taken exhaustive notes on every symptom shown by trees dying from various causes, and from the first it was found necessary to make a thorough examination of the tissue to warrant any degree of accuracy in the diagnosis. From these notes may be had much interesting data on the relative importance of various symptoms. Since some of the poisonous constituents of illuminating gas are absorbed by the roots and are circulated to a certain extent through the tissue of the wood, it becomes necessary to note these substances and learn to detect their presence, either by chemical means or from direct observations and experience.

As already stated, no two species of trees present precisely the same symptoms, much variation occurring from location, seasons, etc. A certain species, for example, examined in the fall, will show slightly different symptoms from those given by a spring examination, and this is true of trees poisoned by gas from different manufacturing plants, due undoubtedly to the fact that there is considerable difference in the gas manufactured by different concerns. The different chemical constituents of the soil in remote localities might to a certain extent be held responsible for the variations in the reaction of gas on the tissues, but this is probably not very important, since these variations are likely to occur even in a single town supplied from one source, and as a rule the symptoms in trees injured by gas from a single manufacturing plant are alike. From tables giving the results of gas analysis from various corporations we find that there is considerable difference in the composition of gas, and furthermore, that gas from a single corporation is likely to vary from day to day to some extent. This variation is not only found in the different percentages of gas constituents but in the other products.

The principal features in the tissues from which diagnosis may be made are odor and color, although it is possible by the use of chemicals to obtain reactions and to detect certain products in the tissue of trees killed by gas. There are different odors associated with the wood of trees which die from various causes, and it is necessary to become familiar with these to be able to differentiate them. Molds and other micro-organisms acting on the sap of trees dying from various causes often cause decomposition, with certain resultant odors which occur in a great variety of trees. But always in trees killed by gas may be found peculiar characteristic odors difficult to describe, even if the tissue most seriously affected is found. This tissue is usually at the base of the tree or in the larger roots near where the tissue has absorbed the most poison, and it is more easily recognized after a tree has been dead for a few weeks or months. The odor is more prominent in moist than in dry trees. It can be detected in the tissues of the bark as well as of the wood.

Sometimes this odoriferous wood is found deeper in the sapwood than at other points, and can be recognized in the stumps of trees freshly cut, but in old stumps where decay has set in it is not always discernible. In such cases some part of the root system, if dug up, is likely to give a characteristic odor except when the wood has become too dry and a more or less advanced stage of decay has set in. As previously stated, the odors are difficult to describe, as they are often associated with the products of decomposition. Moreover, the odors of one tree are entirely different from those of another, so one has to become familiar with the characteristics of each species of tree which he is diagnosing. The natural odor of the maple is quite different from that of the elm, horsechestnut or red oak, and their products of decomposition differ also. Nevertheless, the characteristic odor given to the tissue by the products of illuminating gas can be differentiated quite easily and accurately by any one familiar with them. Sometimes these odors are found in a considerable part of the tissue of the trunk, but more often they are confined to some special part of the tree or root. They are more pronounced by far at the base of the tree than above, and in the top are rarely to be noticed.

We know of no remedies which can be applied to trees already poisoned by gas, since the injury occurs below the surface of the ground, and the effects on the tree are seldom noticeable until the poisoning is more or less pronounced. If the leakage of gas could be discovered quickly and the leak repaired, the effects on the roots might be prevented, but this is rarely the case. In some instances where only one root has been affected, and the poison has not reached the trunk of the tree, amputation of the root is used to prevent further harm, and we have seen cases where this has proved effective. There are many cases where trees have not suffered from gas poisoning although located near large leaks, because in the installation of curbings many of the larger roots were destroyed which grew over the roadbed where the gas pipes were laid.

When the soil is charged with gas, excavating and aerating are beneficial, and in the case of severe leakage it is well to leave the trench open for a few days, if possible. On the other hand, boring holes in the soil and filling with water is of absolutely no value. It is generally believed that if young trees are planted near others which have died from gas poisoning they will not live, but this is true only in part. If the soil is thoroughly saturated with gas, bad results may follow, but if young trees are planted in fresh loam and the old soil aerated there is little likelihood of the tree dying. It is possible, but perhaps at the present time not practical in all instances, to prevent injury to trees and asphyxiation to people in houses from gas leaks, and undoubtedly in the future better methods of distributing gas will be employed.

SUMMARY.

The symptoms of gas poisoning are best obtained from a careful examination of the wood at the base of the tree or the roots. This can be done when the poisonous principles have reached a certain point in their ascent. There are many symptoms accompanying gas poisoning such as a yellowing of the leaves, dropping off, peeling of the bark, presence of certain fungi, etc., but they are of no value in themselves, as these symptoms may accompany other causes of death.

The Effect of Illuminating Gas on Foliage.

Gas from soil leakage seldom escapes into the atmosphere sufficiently to cause direct injury to foliage, although trees are sometimes injured near gas-manufacturing plants, where there is usually a strong odor of gas. Atmospheric gases of all kinds are quickly dispersed, especially when there is any circulation of air; yet under certain conditions they cause injury to plants, as is well known. The leakage of illuminating gas from soil pipes is seldom sufficient in quantity or prolonged enough for it to injure the foliage of trees and shrubs.

The trees in large cities often suffer greatly from atmospheric gases, of which the most injurious are those arising from coal combustion. The escape of illuminating gas into sewers and conduits is not uncommon. If an untrapped greenhouse drainage system connects with a sewer containing gas, the gas is likely to find its way into the greenhouse and injure the plants, and we have known of large greenhouses losing many plants in this way, the gas escaping into the greenhouse for long periods in such minute quantities as to be scarcely perceptible to the sense of smell. Last winter, when the upheaval of the ground from frost did great damage to gas and water pipes, the gas from a leak near our greenhouse found its way to a drain tile leading to the house some distance from the source of leakage, defoliating a large number of our plants in a few hours. A rose plant which was in perfect condition the night before was found the next morning with most of its leaves turned yellow, and 50 or more per cent. of them had fallen. The plants most severely affected were roses, geraniums and abutilon, but ivy, Eucalyptus, India rubber plants, willow, Kenilworth ivy, papyrus, tobacco, tomato and Sedum were also injured. The ferns, mosses and liverworts, which were nearest the gas inlet, were scarcely touched. After being defoliated, the geraniums and abutilon produced numerous small leaves, and the leaves on the variegated abutilon came in entirely green.

Hartig[1] mentions that Camellias, azaleas and ivy are very sensitive to escaping gas, the least sensitive being palms and Dracænas. It would appear that the higher plants are more susceptible to gas than the lower ones. This might be explained on the assumption that the lower plants, being descendants of very old types which in past ages may have been adapted to different atmospheric conditions, possibly inherit a wider range of adaptability, with consequently less liability to injury.

Effects of Illuminating Gas on Carolina Poplars.

Our attention has been called at different times by Mr. James Walker, of the Newark Shade Tree Commission, Newark, N. J., to a peculiar effect which poisoning from illuminating gas has on Carolina poplars (*Populus deltoides* Marsh).[2] This tree is used extensively for shade in New Jersey, but has recently come into disrepute owing to the havoc which its vigorous root system raises with sewers. Some of these characteristic toxic effects consist in a splitting of the bark and swelling and bulging of the tissue near the lesions, and later a slimy, mucilaginous mass exudes from the cracks.

This last season we examined a Carolina poplar which displayed, in addition to the usual symptoms of gas poisoning, this peculiar swelling and cracking of the bark, and some of the tissue was gathered for histological examination. The tree in question was 7 or 8 inches in diameter near the base, and at the time of observation, in common with most trees affected by gas poisoning, had no leaves. The bark, cortex, etc., on the trunk towards the source of absorption showed three or four vertical cracks or lesions ½ to 2½ feet long. The bark on the sides of these cracks was bulged out considerably, and examination showed a thick layer of soft, parenchymous tissue extending to the wood and apparently derived from the cambium zone. This tissue at the time of observation was perfectly white and fresh in appearance, was easily broken and apparently as delicate as the tissue of an apple. Later the tissue turned brown and disintegrated and became slimy in appearance. This breaking down of the tissue takes place in the more advanced stages of disintegration and, according to Mr. Walker, this broken-down mucilaginous substance exudes from the cracks. Specimens of the bark and tissue showed this soft layer, which was thicker directly under the cracks, where the tension was less, to be anywhere from ½ to 1½ inches thick. Microscopic examinations showed the fresh tissue to be composed entirely of thin-walled parenchyma cells.

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[1] R. Hartig, "The Diseases of Trees."

[2] We have heard the opinion expressed at different times that Carolina poplars are immune to gas poisoning, but there is no foundation for this statement.

In the illustration, 1 shows an enlarged cross section of a piece of normal bark; 2, a cross section of the bark near one of the cracks; 3, a cross section of bark and wood and the abnormal parenchymous growth; and 4, a cross section of the normal bark, including some of the wood. In 2 and 3 the abnormal growth is shown at *e*. In 3, which is an enlarged section, the nature of the tissue is readily seen, as well as its origin from the cambium *f*. In 5 is shown a diagrammatic cross section of tree, with lesions.

This peculiar cracking characteristic of Carolina poplars poisoned by gas has never been observed by us in other species, although like effects have been noticed in willow cuttings growing in water charged with gas, in which case we have often noticed a splitting of the bark and slight swelling, followed by the formation of a mucilaginous mass under the bark. The bark of most trees poisoned by illuminating gas remains intact until it becomes very dry and brittle, and then it cracks, curls up and eventually falls off. There is, however, no disposition in other trees, so far as noticed, for the tissue to become mucilaginous. In some cases of poisoning of coniferous trees the bark may become ruptured and a copious flow of pitch follow. This tissue is apparently what is termed by Hartig "wound cambium," and we have never seen it forming on poplars as the result of ordinary mechanical wounds.

During the past season we have noticed a number of cracks on small poplars (*Populus tremuloides*) apparently resulting from frost injury. But in this case there was no abnormal development of the cambium.[1]

When banding substances are applied to Carolina poplars

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[1] The injection of poisons into tissue is said to cause a rupturing of the tissue owing to changes in the turgescence of the cells.

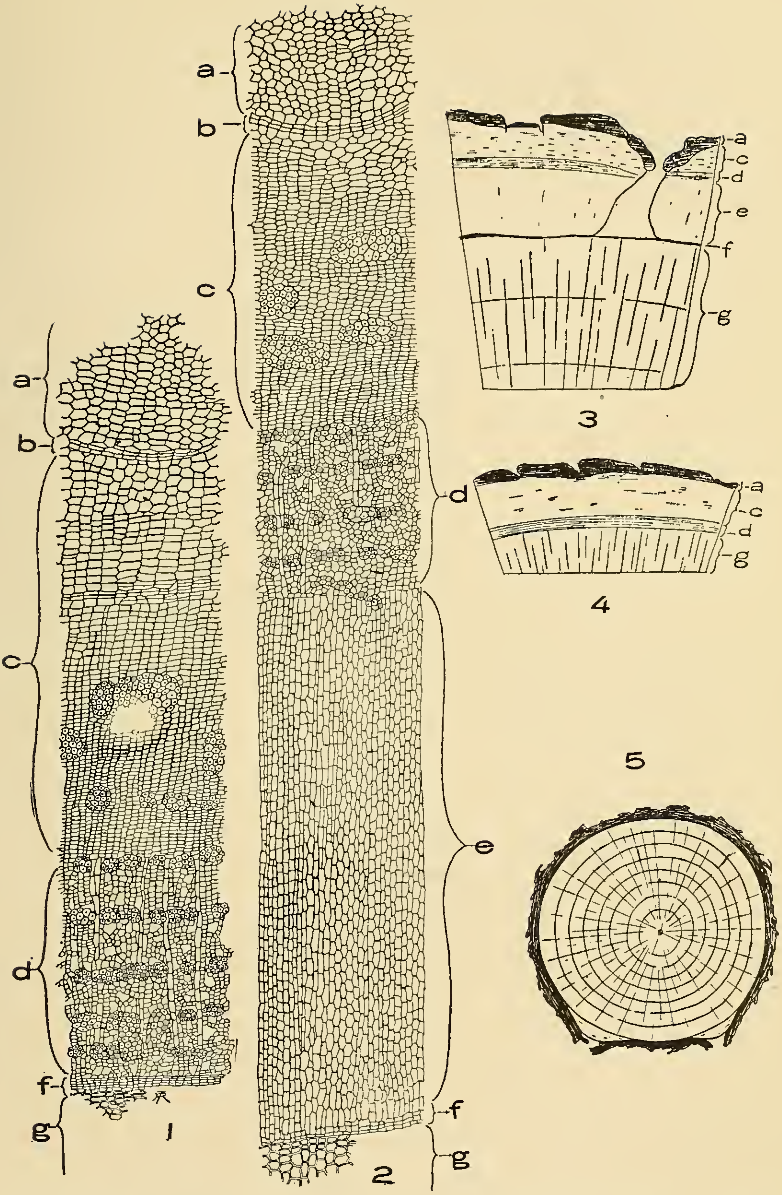

FIG. 1.—Showing cross section of Carolina poplar (*Populus deltoides* Marsh). 1, Cross section of normal stem, enlarged; 2, same, showing abnormal growth; 3, naked-eye view of same; 4, section of a normal stem; 5, cross section of trunk of tree showing the splitting of the bark; *a*, bark; *b*, cork cambium; *c*, cortex; *d*, phloem; *e*, abnormal parenchyma; *f*, cambium; *g*, wood or xylem.

and other trees to trap insects, injury often results to the tissue, with swellings and distortion where the substances come in contact with the bark. We have seen many trees affected in this way in the eastern part of the State, where much use has been made of banding substances for the extermination of the gypsy moth. Their effect is more pronounced on Carolina poplars than on other trees, and it is not improbable that this cracking and abnormal formation under the bark results from decreased turgescence of the cell and destruction of the outer tissue, thus relieving the tension on the inner tissue and causing the cambium to divide. With the release of the pressure outwards, it is natural for this tissue to extend in this direction, thus rupturing the outer bark. The absorption of the gas may have killed the tissue exterior to the cambium layer before the cambium was affected. In this way, the tension of the outer tissue being diminished, a stimulation of the cambium cells results.

The poisonous constituents of gas have a direct stimulating effect on the cells during the incipient stage of poisoning, as observed in the case of willow cuttings, etc.; but in this instance it would appear that the excessive development of the cambium was caused by the diminished tension of the cortical tissue.

Stimulating Effects of Illuminating Gas on Willow Cuttings.

For many years we have been studying the effects of different gases on the functions of plants, and during this time we have made many experiments relative to the effects of water charged with illuminating gas on the development of willow cuttings. It is well known that there are many chemical substances which stimulate plants. Even the most violent poisons, if administered in certain dosages, will greatly increase plant activities; for instance, ether is well known to cause latent buds to blossom, and some use is made of it by commercial florists.

Illuminating gas is a deadly poison both to the foliage and root systems of plants; but when administered under certain conditions is a great stimulant. Latent willow cuttings grown in water charged with illuminating gas for a few moments every day or two showed a greatly increased development, producing foliage several days earlier than plants grown in water not charged with gas.

The results of experiments with latent willow cuttings grown under these conditions are shown in Table I. The cuttings were grown in glass jars containing about 2 litres of water which was charged at different periods, as shown in the following table: —

TABLE I. — *Showing Stimulating Effects of Illuminating Gas on Willow Cuttings grown in Water charged with Gas.*

[In all experiments except No. 1, 8 normal and 8 treated cuttings were used in each series.]

EXPERIMENT.		First Appearance of Leaves and Shoots.	Gain in Development (Days).	Water charged with Gas for a Brief Period.
1	Normal,	August 19	9	Every second day.
	Treated,	August 10		
2	Normal,	December 10	8	Every second day.
	Treated,	December 2		
3	Normal,	January 4	8	Every second day.
	Treated,	December 27		
4	Normal,	December 29	6	Every second day.
	Treated,	December 23		
5	Normal,	February 4	11	Every second day.
	Treated,	January 24		
	Treated,	January 22	9	Every fourth day.
	Treated,	January 24	11	Every sixth day.
6	Normal,	February 20	5	Every second day.
	Treated,	February 15		
7	Normal,	March 25	6	Every seventh day.
	Treated,	March 19		
8	Normal,	April 24	5	Every second day.
	Treated,	April 19		
	Treated,	April 20	4	Every fourth day.
9	Normal,	July 18	4	Every second day.
	Treated,	July 14		

The data given in this table show that the willow cuttings contained in the charged jars developed new shoots and foliage from four to eleven days earlier than those grown in jars containing the ordinary uncharged tapwater. They also show that

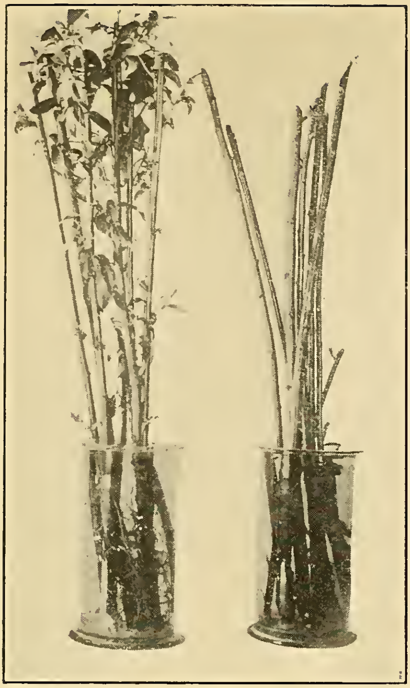

FIG. 2. — Showing willow cuttings growing in water; those to the right, in ordinary water, those to the left, in water charged with gas.

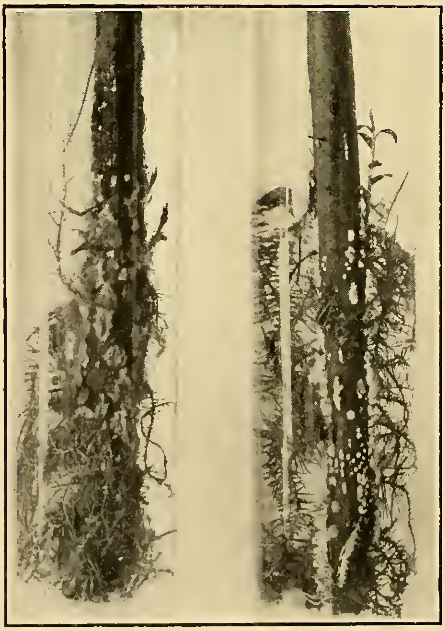

FIG. 3. — Showing development of lenticels on willow cuttings growing in water. Figure to the right growing in ordinary water; to the left, in water charged with gas.

there is practically no difference in the development of the cuttings, whether the jars were charged with the gas every second day, every fourth day, etc. (Fig. 2).

The duration of these experiments was from one to two months. In some instances the plants showed more or less advanced symptoms of gas poisoning at the close of the experiment, and the oftener the water was charged with gas the quicker the symptoms appeared and the more pronounced the poisoning. The same stimulating effects were shown on the roots as on the stems and leaves.

Table II. gives the results with both shoots and roots as determined by the average length, as follows: —

TABLE II. — *Showing the Stimulating Effects of Illuminating Gas on Willow Cuttings grown in Water charged with Gas.*

[Eight treated and 8 untreated cuttings used in each series. All measurements given in centimeters.]

EXPERIMENT.		AVERAGE LENGTH OF —		PERCENTAGE GAIN IN AVERAGE LENGTH OF —	
		Shoots.	Roots.	Shoots.	Roots.
1	Normal,	2.50	2.00	-	-
	Charged every second day,	6.00	8.00	140	300
2	Normal,	1.50	2.00	-	-
	Charged every second day,	5.00	6.00	233	200
3	Normal,	1.00	3.00	-	-
	Charged every second day,	4.00	6.00	300	100

In this table the average length of stems and roots is given, together with the per cent. gain in average length of each. Only three experiments are given. It will be noticed that there was considerable gain in the average length of roots and shoots of the cuttings grown in gas-charged water.

Another similar series of experiments is shown in Table III., as follows: —

TABLE III. — *Showing the Stimulating Effects of Illuminating Gas on Willow Cuttings grown in Water charged with Gas.*

[Eight untreated and 8 treated cuttings used in each series. All measurements in centimeters.]

	EXPERIMENT.	Total Number of Times charged.	TOTAL NUMBER OF —		TOTAL LENGTH OF —		AVERAGE LENGTH OF —		PERCENTAGE GAIN IN AVERAGE LENGTH OF —	
			Shoots.	Roots.	Shoots.	Roots.	Shoots.	Roots.	Shoots.	Roots.
1	Normal,	-	8	9	2.00	11.10	.25	1.20	-	-
	Charged every second day,	15	53	82	164.00	294.00	3.09	3.58	1,096.00	198.38
2	Normal,	-	35	40	178.50	196.00	5.10	4.90	-	-
	Charged every second day,	34	36	156	212.40	113.88	5.90	7.30	15.68	48.98
3	Normal,	-	30	42	125.60	111.10	4.18	2.64	-	-
	Charged every second day,	24	24	142	161.30	703.90	6.72	4.95	36.89	87.50
	Charged every fourth day,	12	32	161	178.60	1,000.10	5.58	6.21	33.49	135.22
4	Charged every sixth day,	6	30	151	204.70	753.20	6.82	4.98	63.15	88.67
	Normal,	-	32	39	140.90	104.40	4.40	2.67	-	-
	Charged every second day,	24	13	127	162.20	677.90	12.47	5.33	183.40	99.90
	Charged every fourth day,	12	38	131	344.50	932.90	9.07	7.12	106.10	166.60
	Charged every sixth day,	8	30	145	295.10	776.40	9.83	5.35	125.60	100.40

Summary of Table III.

	Number of Plants.	Average Number of —		Average Length in Centimeters of —		Per Cent. Gain in Average Length of —	
		Shoots.	Roots.	Shoots.	Roots.	Shoots.	Roots.
Normal, . . .	32	26	32	111.75	105.90	-	-
Treated, . . .	64	32	138	215.35	656.53	92.7	519.9

This series of experiments was conducted like the preceding, except that measurements were made of the total number and length of shoots and roots, which was greater in the gas-charged water. The average number of shoots in the treated water was 32, and of those in the normal or untreated, 26, while of the roots, the average for the treated water was 138 and for the untreated, 32. The stems and roots in the charged water greatly exceeded in development those in the untreated water, and appeared much earlier.

From these data it will be seen that the effects of gas in increasing the number of roots are quite noticeable. Similar results are shown with the total length of shoots and roots; for instance, the cuttings growing in the charged water grew longer roots and shoots than those in the untreated water. It will also be noticed that the total length of roots is relatively greater than the total length of shoots. The average total length of the normal, untreated shoots was 111.75 centimeters, of the treated shoots, 215.35 centimeters. The average length of the normal roots was 105.90 centimeters, and that of the treated, 656.35 centimeters. The average gain of the treated over the untreated shoots was 92.7 per cent., and that of the treated over the untreated roots was 519.9 per cent. The percentage gained in average length of shoots and roots in each experiment ranges from 15 to over 1,000 per cent. in favor of those grown in gas-charged water.

In summarizing the results of these experiments it may be said that there was little difference in the average number of shoots in the normal and treated, but the average number of roots in the treated shoots exceeded those of the normal; furthermore, the total and average length of roots and shoots in the treated water greatly exceeded that in the untreated. While only a slight difference was shown in the number of shoots in the normal and treated willow cuttings, the latter showed a greater development. The increased development of the shoots and foliage was correlated with the greater root development. We regard the increased root development of the treated willow cuttings as a direct response to oxygen supply. The roots of cuttings growing in the charged water were invariably more slender than those in the untreated, and were also characterized by an early appearance of a profuse growth of secondary roots.

Effects of Illuminating Gas on Lenticels.

The lenticels or breathing pores of the willow cuttings grown in water charged with gas showed a marked difference in development. They always show a greater growth in water, but the development of the parts submerged in water charged with gas was exceptional. Many years ago Nobbe[1] observed when conducting water culture experiments with potatoes that the submerged tubers developed unusually large lenticels.

This stimulation of the lenticels was one of the most conspicuous reactions we observed in our experiments with willow cuttings, and appears to be a general response to a demand for oxygen. (Fig. 3). The gas in the treated water had practically the same asphyxiating effect on the plant as a decreased supply of oxygen, the demand for oxygen being increased and the plant responding by a greater growth of the lenticels.

The response on the part of the roots of the willow cuttings to the stimulating effects of gas appears to be the same type of reaction, *i.e.,* practically amounting to a decreased oxygen supply. Observations on plants grown under a diminished atmospheric pressure have given somewhat similar results to those shown by the willow cuttings; that is, they grow more rapidly than those under normal conditions. This is not, however, the effect of the diminished pressure alone, but is due to a diminution of the partial pressure of oxygen. Wieler and Jaccard[2] have demonstrated that the optimum growth of plants does not correspond to the normal atmospheric pressure. According to Jaccard, a decrease in the pressure of oxygen gives rise to an accelerated growth and more profuse branching of the axis and roots, together with an increase in the size of the leaves. The water containing gas is taken up in small quantities by the roots and translocated to the stem and leaves, and since plants possess considerable power of accommodation they can do this for quite long periods without injury.

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[1] Landwirtsch. Versuchstation, Vol. IV., 1864, p. 60.

[2] Schimper's Plant Geography, p. 69.

Plants, like animals, respond to stimuli arising from various causes, and while plants may not respond as quickly as animals, their sensitiveness is in many instances more acute. Specific stimuli give rise to definite responses, and the nature of the response usually corresponds with some immediate need of the organism. The presence of water charged with gas in the plant tissues stimulates the demand for oxygen, which is manifested in a greater root development and leaf surface.

Man and animals respond characteristically when subjected to a decreased oxygen supply such as is caused by unusual exertion like mountain climbing, running, etc. Dogs open their mouths, run out their tongues and breathe more rapidly when excited, and this is in reality a response to the demand for more air or oxygen. In the same way, the increased size of lenticels is a direct response to the demand for oxygen, although in the case of both animals and plants it is purely reflex and involuntary.

Illuminating Gas as a Factor in Forcing the Development of Plants.

The stimulating effects of gas-charged water on willow cuttings led us to experiment with illuminating gas in other ways, therefore a number of experiments were made to determine the effects of atmosphere charged with the gas on the development of dormant willow cuttings. Ether and other substances have been used to stimulate plants in a dormant condition, and we wished to learn whether gas would have the same effect.

The willow cuttings were placed under sealed bell jars in vessels of water and subjected to an atmosphere of illuminating gas for twenty-four, forty-eight, seventy-two, ninety-six and one hundred and twenty hours, respectively. A number of cuttings were used in each test, and after being treated for these different periods they were removed from the bell jars and placed under greenhouse conditions to await the results of treatment. When these cuttings were compared with untreated or normal plants, as they were in all cases, a slight acceleration was found in the development of all plants subject to gas for twenty-four, forty-eight and seventy-two hours, although the gain was not marked.

THE INFLUENCE OF VARIOUS LIGHT INTENSITIES AND SOIL MOISTURE ON THE GROWTH OF CUCUMBERS, AND THEIR SUSCEPTIBILITY TO BURNING FROM HYDROCYANIC ACID GAS.

G. E. STONE.

The influence of light on photosynthesis, structure and development of plants is well known to plant physiologists, but is too little appreciated by growers of crops, whether under glass or in the field. It is also well known that plants grown in the dark are pale and slender, with undeveloped leaves, and they quickly wilt and die when exposed to different temperatures and light conditions. The variations in light intensity in the greenhouse or in the field, such as occur in periods of cloudy weather, affect crops greatly. There are many features connected with greenhouse construction, such as inferior or dirty glass, angle of the roof, heavy shadow-casting frames and others which also play an important part in plant development. Certain light-requiring crops grown under the inferior light conditions of November and December develop abnormally, and often suffer greatly from wilts in the spring when the light is more intense. The plants possess light-colored, thin leaves, elongated and slender internodes and leaf petioles, and, in fact, are in a state of partial etiolation.

Light inhibits growth and has a remarkable effect on the texture of plant tissue. While it has a great deal to do with the non-ripening and ripening of wood, moisture, temperature and other factors also enter in.

The successful growing of lettuce under glass requires exceptional skill, as much attention has to be given to the influence of light, moisture and other factors on the crop to prevent what is termed "topburn," a certain texture being required to do this. Even a difference of a few degrees in the night temperature exerts marked influence on the texture of the tissue. Lettuce plants which are grown under a night temperature of 45° F. differ greatly from those grown at a temperature of 50° F., the structure of the plant being modified for each degree of increase or decrease in the temperature. With the lower night temperature there is less likelihood of burning than with the higher. If a night temperature of 50° F. is maintained during cloudy weather, and on a following bright, sunshiny day the temperature is allowed to reach 75 or 80° F., topburn is likely to occur. On the other hand, a night temperature of 40° F., during cloudy periods followed by a relatively high day temperature, is not likely to produce any burning.

Light has a marked accelerating effect on transpiration, as the stomata of the leaves open in bright sunshine, and the loss of water from the foliage under these conditions is large. In the blossom end rot of tomatoes, a disease caused primarily by heavy drainage of water from the fruit during its development, we have noted a difference of 35 per cent. in the amount of rot, caused by the shading of the tomato plants by other plants, reducing the transpiration.

Practical growers who have had occasion to fumigate greenhouses to destroy aphis, white fly and thrips have observed that their plants will burn slightly at one time and at other times not; for instance, hydrocyanic acid gas, tobacco leaves or concentrated solutions of tobacco, and other fumigants sometimes cause injury to plants and at other times produce no burning. This is also true of spraying mixtures, whether used in the greenhouse or field.

The experiments given here are designed to show some of the causes underlying burning from fumigation, and were made by Mr. F. L. Thomas during his course as a graduate student. The plants selected were cucumbers, as they are susceptible to burning from various causes, and are also affected greatly by variations in light intensity. The plants were grown under five cloth screens, ranging in grade from mosquito netting to rather finely woven cotton material, each covering a space 2 feet wide, 6 feet long and 2 feet high on a long bench in the greenhouse.

The normal plants were grown in the same bench but were not screened, and the light conditions were the same as those in the greenhouse. The house is new and the light excellent, — only about 18 per cent. less than out of doors. The relative light intensity under the various conditions varied sufficiently to cause considerable difference in the development of the plants. These differences were determined by chemical methods accurate enough to warrant the average relative light conditions being obtained, but not adapted to measure the absolute light intensity.

In the following tables are given the results of experiments with the effects of different light intensities on the growth of cucumber plants and their susceptibility to burning from hydrocyanic acid gas. In each experiment 6 groups of plants were used, No. 5 being grown under normal greenhouse conditions and the others under varying light intensities.

Since two of the screened compartments gave practically the same light intensities, and the results obtained from the plants in these sections were similar, they were averaged together and appear in the table under No. 2. The plants were grown in 7-inch pots and entirely under the screens. The moisture content of the soil was kept fairly uniform in each series. After the plants had reached a certain degree of development they were placed in a tight glass case containing about 30 cubic feet, and each series was fumigated at the same time under similar conditions as regards exposure and the amount of hydrocyanic acid gas. The plants were all fumigated with .007 grams of cyanide per cubic foot, a strength commonly used in greenhouse work, and known as formula[1] 1–2–3, — one part cyanide, two parts sulfuric acid and three parts water. After undergoing this treatment for forty minutes to one hour the plants were removed from the case and the results noted.

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[1] Bul. 123, Mass. Agr. Exp. Station, 1903.

TABLE I. — *Showing Effects of Different Light Intensities on the Growth of Cucumber Plants and their Susceptibility to Burning by Fumigation with Hydrocyanic Acid Gas.*

EXPERIMENT I. — *Duration, May 2 to June 6.*

[Measurements in centimeters.]

	NUMBER.				
	1.	**2.**	**3.**	**4.**	**5 N.**
Relative light intensity (per cent.),	24.4	26.60	48.10	74.00	100.0
Average height of plants,	13.0	20.10	11.00	17.00	16.0
Average diameter of stem,	.4	.57	.45	.65	.8
Average length of internodes,	5.0	5.90	4.20	4.00	3.7
Leaf: —					
Average length,	7.5	8.60	5.20	9.90	8.7
Average width,	6.5	9.00	6.20	9.20	10.5
Length by width,	48.7	77.10	32.20	91.00	91.3

NOTE. — No. 1, all leaves killed; No. 2, leaves burned, few killed; Nos. 3, 4 and 5 N, traces of burning.

EXPERIMENT II. — *Duration, May 8 to June 13, 1911.*

[Measurements in centimeters.]

	NUMBER.				
	1.	**2.**	**3.**	**4.**	**5 N.**
Relative light intensity (per cent.),	24.4	26.60	48.10	74.0	100.0
Average height of plants,	30.5	28.30	2.10	27.2	16.0
Average diameter of stem,	.5	.62	.55	.7	.8
Average length of internodes,	8.2	6.60	6.60	4.7	3.5
Leaf: —					
Average length,	9.0	8.10	6.00	5.5	6.2
Average width,	10.5	11.50	9.00	9.5	12.5
Length by width,	94.5	93.70	54.00	52.2	77.5

NOTE. — No. 1, burned; some leaves killed; Nos. 2 and 3, some burning; Nos. 4 and 5 N slight burning.

EXPERIMENT III. — *Duration, May 22 to June 24, 1911.*

[Measurements in centimeters.]

	NUMBER.				
	1.	**2.**	**3.**	**4.**	**5 N.**
Relative light intensity (per cent.),	24.40	26.60	48.1	74.00	100.00
Average height of plants,	23.50	23.30	20.0	15.70	14.70
Average diameter of stem,	.42	.55	.6	.65	.75
Average length of internodes,	8.70	8.60	7.1	4.45	4.85
Leaf: —					
Average length,	8.50	9.90	9.7	8.70	8.20
Average width,	8.20	10.30	10.5	11.20	10.70
Length by width,	69.70	100.30	101.8	97.40	87.70

NOTE. — No. 1, burned; No. 2, burned; No. 3, slight burning; Nos. 4 and 5 N, no burning.

Summary Table.

[Measurements in centimeters.]

	Number.				
	1.	2.	3.	4.	5 N.
Relative light intensity (per cent.),	24.40	26.60	48.10	74.00	100.00
Average height of plants,	22.30	23.30	17.30	19.90	15.50
Average diameter of stem,	.44	.53	.53	.66	.78
Average length of internodes,	7.30	7.00	5.90	4.30	4.00
Length by width of leaves,	70.90	90.30	62.60	80.20	85.50

It will be noticed that the difference in development of the plants in the preceding experiments arises from the fact that they were growing under varying light intensities. Many physiologists, particularly Wiesner, have studied the effects of light intensities on the conformation of plants, and it is necessary, therefore, to mention only in a general way the modifications caused by light. Altogether too few plants were used to eliminate the differences arising from individual variation; nevertheless, the summary table shows a more or less uniform variation in the development of the plants due to different light intensities.

No. 5N, which was growing in the greenhouse, was taken as a normal for growth comparison. The light conditions for this plant were taken as 100 per cent., and represent those characteristic of our latitude at the time the experiments were made, minus an average loss of about 18 per cent. from the greenhouse glass. No. 4, which was screened, received only 74 per cent.; No. 3, 48 per cent.; No. 2, 26 per cent. and No. 1, 24 per cent. These percentages, of course, are purely relative, and are based on the assumption that the plants under normal conditions in the greenhouse received 100 per cent. of light. It will be observed that most of the injury occurred to those plants growing under the poorest light conditions, and the least where the light conditions were best. In considering the results as given in the summary table, which are more reliable than those in the other tables, as they represent averages, much difference is shown in the development. The greatest average height of the plants and length of internodes were found in those series where the light was less, while, on the other hand, the shortest internodes and greatest diameter of the stems occurred in those plants which received the most light; but the average length and width of leaf were variable, as shown in the table. The data giving average length and width of the leaves were obtained by multiplying the width by the length, and represent fairly well the size of the leaf.

It will be noted that the plants growing where the light was excluded had the largest leaves. The leaf development, of course, varies according to the season, and is also affected by light exposure, methods of pruning, etc., and greenhouse cucumbers usually have much larger leaves than field cucumbers. Whatever the optimum photosynthetic requirements for cucumbers may be, or what relationship exists between the size of the leaves and optimum photosynthesis, we do not know; but the production of larger leaves under certain light intensities is apparently a response to a demand for greater carbon assimilation.

To summarize the results of these experiments: burning from hydrocyanic acid gas is more extensive on plants grown under poor light conditions than where the light is good, showing that weak tissue, such as is produced by inferior light, is more susceptible to burning from fumigation.

Influence of Varying Percentages of Moisture on the Development of Cucumbers and their Susceptibility to Burning from Hydrocyanic Acid Gas.

That the percentage of moisture in soil has an important bearing on crop production, exerting a modifying influence on growth and development, is well understood and usually taken into consideration by experimentalists. Plants will make greater growth in a relatively moist soil, although there is an optimum moisture content of the soil for most plants. Besides growing more rapidly, a plant in a moist soil develops a different type of tissue, which is usually less resistant to various injurious agencies than the dry soil plant. Two or 3 per cent. more water in a plant than what might be considered the normal renders it more susceptible to winter killing, topburn and even fungous infection. Lettuce, for instance, will burn more quickly when the tissue contains more than the usual amount of water, and mildew and rusts are more common on plants with a relatively high water content.

The object of our experiments in growing plants in different percentages of soil moisture was to determine what influence soil moisture had on the development of the plant, with special reference to susceptibility to burning from hydrocyanic acid gas. We used cucumber plants, as before, growing them in small, galvanized iron pots holding about 1½ kilograms of soil. The soil was the greenhouse type, containing considerable organic matter, with a water-retaining capacity of 47 per cent. The total water-retaining capacity of the soil in these experiments was regarded as 100 per cent. The various soils in the pots were maintained at 10, 20, 50 per cent., etc., of the total water-retaining capacity.

After reaching a certain degree of development under greenhouse conditions the plants were placed in a tight case, as in the preceding series of experiments, and treated with .007 grams of cyanide per cubic foot, as before. After treatment the plants were taken out of the case and left for further observations.

TABLE II. — *Showing the Effects of Different Percentages of Soil Moisture on the Growth of Cucumber Plants and their Susceptibility to Burning from the Use of Hydrocyanic Acid Gas.*

EXPERIMENT I. — *Duration, June 5 to June 20.*

[Measurements in centimeters.]

	NUMBER.				
	1.	2.	3.	4.	5.
Per cent. moisture,	10.000	25.0	40.00	55.00	70.00
Average height,	3.300	6.5	8.00	10.50	2.70
Average length of internodes,	2.000	4.7	6.00	4.00	2.00
Average length of petioles,	.750	2.0	3.75	3.66	.75
Average diameter of stem,	.275	.4	.45	.50	.30
Average length by average width of leaf,	1.000	3.0	4.50	4.75	2.00

NOTE. — Nos. 1, 2 and 3, no burning; Nos. 4 and 5, burned.

EXPERIMENT II. — *Duration, March 12 to April 11, 1912.*

[Measurements in centimeters.]

	Number.					
	1.	2.	3.	4.	5.	6.
Per cent. moisture,	10.00	15.0	20.0	50.0	60.0	70.0
Average height,	6.50	8.0	11.0	14.0	18.0	21.5
Average length of internodes,	4.50	4.5	6.0	7.0	8.0	8.0
Average length of petioles,	1.50	1.5	2.5	3.0	4.0	3.0
Average diameter of stem,	.30	.3	.4	.4	.6	.5
Average length by average width of leaf.	6.25	52.0	59.0	185.2	300.0	276.0

NOTE. — Nos. 1 and 2, no burning; No. 3, slight burning; Nos. 4, 5 and 6, nearly all leaves burned.

EXPERIMENT III. — *Duration, March 12 to April 11, 1912.*

[Measurements in centimeters.]

	Number.					
	1.	2.	3.	4.	5.	6.
Per cent. moisture,	10.00	15.0	20.0	50.0	60.0	70.0
Average height,	6.00	7.0	9.5	12.0	17.0	21.0
Average length of internodes,	4.00	4.5	4.5	4.0	7.0	8.5
Average length of petioles,	1.20	2.0	2.0	3.5	4.0	3.5
Average diameter of stem,	.30	.3	.4	.5	.5	.5
Average length by average width of leaf.	6.25	27.0	76.0	140.0	150.0	320.0

NOTE. — Nos. 1 and 2, no burning; No. 3, slight burning; Nos. 4, 5 and 6, nearly all leaves burned.

Summary Table, Experiments II, and III.

[Measurements in Centimeters.]

	Number.					
	1.	2.	3.	4.	5.	6.
Per cent. moisture,	10.00	15.0	20.0	50.00	60.00	70.0
Average height,	6.20	7.5	10.2	13.00	17.50	21.2
Average length of internodes,	4.20	4.5	5.2	5.50	7.50	8.2
Average length of petioles,	1.30	1.7	2.2	3.20	4.00	3.2
Average diameter of stem,	.30	.3	.4	.45	.55	.5
Average length by average width of leaf.	6.25	39.5	67.5	162.50	225.00	285.0

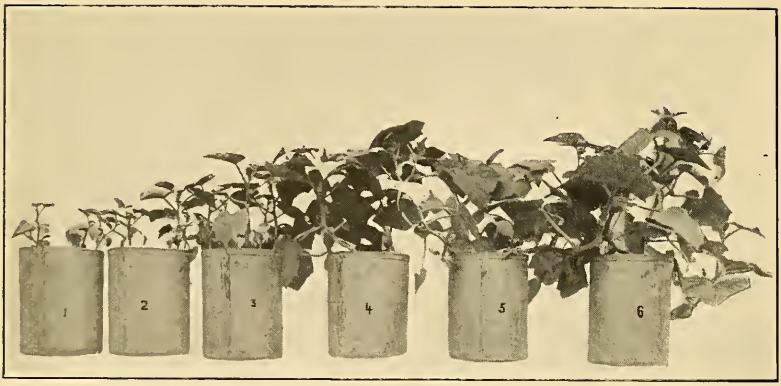

FIG. 1. — Showing cucumber plants growing in different percentages of moisture. No. 1, in 10 per cent.; No. 2, in 15 per cent.; No. 3, in 20 per cent.; No. 4, in 50 per cent.; No. 5, in 60 per cent.; No. 6, in 70 per cent. of the total moisture contents of the soil.

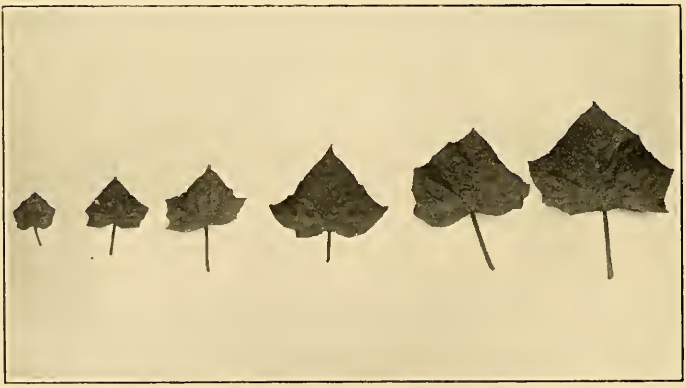

FIG. 2. — Showing leaves taken from cucumber plants grown in different percentages of moisture, corresponding to those shown in Fig. 1.

In the preceding table it is shown that different percentages of soil moisture exert a marked influence on the development of the plants, and their susceptibility to burning from fumigation. It will be noticed (see Summary Table) that the average height of the plants was greater and the leaves larger in the pots containing the largest percentage of water. (*Cf.* Figs. 1 and 2.) Also the diameter of the stems and length of leaf petioles and internodes was greater in the plants growing in a higher percentage of soil moisture, although in the case of the plants growing in pots containing 70 per cent. of water there was too much moisture for the best development.

In Experiment I. the water was supplied largely to the surface of the soil, and in II. and III., below the surface. The plants growing in soil containing over 50 per cent. of moisture burned most severely, while those in soil containing less were not affected nearly so much, showing the extent of injury to be proportionate to the amount of soil moisture. Examination of some of the leaves under a microscope showed much variation in the number of stomata. The upper leaf surface of a cucumber plant grown under normal moisture conditions had 27 stomata to the square millimeter, while that of a plant grown in soil containing 10 per cent. of moisture had only 11.

Those who have used cyanide to any extent in greenhouses are well aware that it has a rather narrow range of safety, and that burning will occur at one time and not at another when the conditions are apparently identical. Most fumigating is done after dark, and it is usually customary to first wet down the greenhouse, on the idea that if the house is well filled with moisture, fumigation is more effective, especially when tobacco is used; and by fumigating after dark less injury is supposed to result from burning of the foliage. This latter notion is based on the assumption that the leaf stomata close in darkness, and therefore less gas is absorbed by the foliage, and burning is not likely to occur.

There are numerous factors associated with the burning of foliage by fumigation which are not well understood. The effect of sunlight and atmospheric moisture, etc., on the burning of tomatoes and cucumbers has been studied by Dr. H. T. Fernald, Mr. W. V. Tower and Dr. C. H. Hooker[1] in the entomological greenhouse. They found that sunlight, cloudy weather, moonlight, drops of water remaining on the foliage and too high a moisture content of the atmosphere were all conducive to burning, and that less burning occurred on cloudy nights or clear nights without moonlight. The best results were obtained by fumigating on clear, starlight nights, with little or no moonlight, or on dry, cloudy nights with a temperature range of 55° to 65° F.

Some observations recently made by Mr. S. S. Crossman in our laboratory show among other things that the stomata or breathing pores, as always believed, close quite rapidly when subjected to darkness, and open in the sunlight, and that various gases result in a closing of the stomata. Mr. Crossman did not have an opportunity to finish his work, but Mr. G. H. Chapman, research assistant, intends to continue it the coming year. If the burning of leaves is caused by gases entering the stomata, and if the stomata are closed by gases, then it is not apparent why foliage should burn more severely in the daytime than at night. Some experiments made a few years ago in our laboratory by Mr. H. M. Jennison, on the effects of various gases on transpiration, showed that when plants are subjected to gases transpiration decreases rapidly, but in most of these experiments, as well as in some of our own with illuminating gas, there occurs a secondary rise in the transpiration curve shortly after the first drop. From these experiments it would appear that various gases cause a marked retardation in transpiration at first, followed by a brief but marked acceleration, after which a general retardation in transpiration follows.[2] It is possible that the stomata of the gas-treated plants may open again shortly after being closed by the gas, and finally close again. Observations on this point, however, are not sufficient for us to draw any definite conclusions.

The effect of burning on foliage is varied, in some cases merely the margin of the leaves being burned. Sometimes burning takes the form of numerous small spots on the leaf, and this would appear to prove that burning takes place through the stomata. In other cases burning appears in more or less large, irregular spots scattered over the leaf, which was the case in these experiments. The margins of the leaves of cucumbers at times become injured from excessive transpiration, the thin and apparently less developed tissue farthest from the water supply being most susceptible. From the nature of many of the burnings resulting from fumigants in these experiments, it does not appear that the condition of the stomata has anything to do with the susceptibility to burning, but is due rather to the condition of the tissue. The experiments bear out this conclusion, it being found that the plants grown under conditions calculated to develop a less resistant tissue are the ones which burn most severely, and that any condition which has a tendency to develop immature tissue favors injury from fumigants. Other factors, such as the continued use of too high temperatures, and probably in some cases certain fertilizers and stimulated growth from various causes such as pruning, growing in sterilized soil, electrical stimulation, etc., bring about the formation of tissue susceptible to burning; and while burning may be associated in some cases with the condition of the stomata and with the process of photosynthesis, the development of the cuticle and texture of the tissue in general plays an important part. In plants growing under more or less dense shade Mr. Thomas noticed, as anticipated, that the epidermis was more poorly developed than that of those plants growing under better light conditions, and that the hairs on the leaves of the well-lighted plants were much larger and more numerous than those on the leaves of the poorly lighted plants. Ecologically, hairs are for the purpose of modifying the effect of light and transpiration, but whether their presence has any bearing on susceptibility to burning was not learned. The difference in the number of stomata on the upper surface of the leaves of plants growing under varying moisture conditions is evidently an adaptation to transpiration.

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[1] Twenty-first Ann. Rept., Mass. Agr. Exp. Station, 1909, p. 73; Twenty-second Ann. Rept., Mass. Agr. Exp. Station, 1910, p. 214.

[2] Jumelle found (see Schneider, Bot. Gaz., Vol. XVIII,. p. 57) that sulfuric ether increased transpiration in light and retarded it in darkness, while Schneider found that by this treatment transpiration was retarded under all conditions.

As regards the various factors associated with burning, such as light, atmospheric moisture, temperature, etc., we are in need of more experimental evidence relating to the specific rôle which each factor may play. The experiments of Dr. Fernald and Messrs. Tower and Hooker, already referred to, were not all made at the same time, which unfortunately introduces a varying factor. They observed that drops of water on the foliage caused burning. Burning often results from fungicides remaining in a liquid form for even a brief period on the foliage. Water apparently absorbs hydrocyanic acid gas, since we have found that trout, which are very susceptible to this gas, located in an aquarium outside the compartments in greenhouses being fumigated with this gas, are killed, although goldfish do not seem to be affected.

While these experiments do not throw light on all the factors involved in susceptibility to burning, they do demonstrate that burning by fumigation with hydrocyanic acid gas is induced by a difference in the development of the tissue, whether brought about by inferior light conditions or excessive moisture in the soil, the more poorly developed tissue being more susceptible to burning. Further experiments are being conducted in our laboratory to throw more light on the influence of other factors on burning.

The most important practical feature brought out by these experiments is that fumigation should be done only when the plants are in the right condition. Any expert gardener can determine at a glance whether his plants are developing normally, and under glass he can control the environment to a large extent. Care should be used in fumigating during periods of cloudy weather, as under these conditions the same amount of resistant tissue is not developed. Low night and day temperatures, as well as a decrease in the soil moisture, counteract this to some extent, but the presence of light is the most important factor in developing resistant tissue. Fumigation will cause less injury following bright than cloudy weather, and should not be done for two or three days after a cloudy period, so that the plants will have a chance to harden up their tissue. Plants growing in relatively dry soils are affected to a less degree by fumigation than those in moist soils. The same care and attention should be given to prevent injury from fumigation that is used by lettuce growers to prevent topburn.

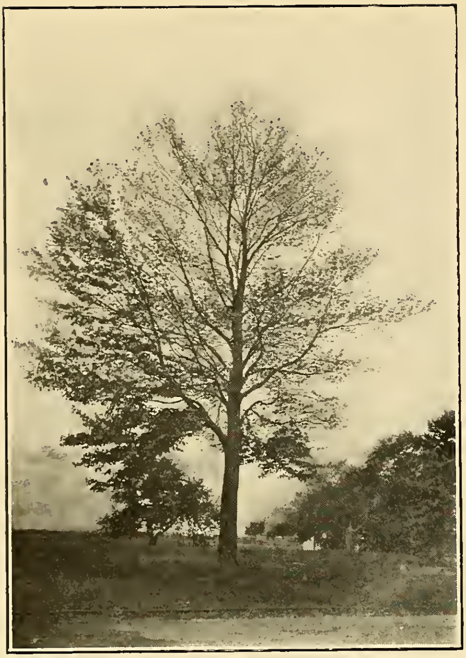

FIG. 1. — Showing red maple, alive, but with inferior foliage at the top.

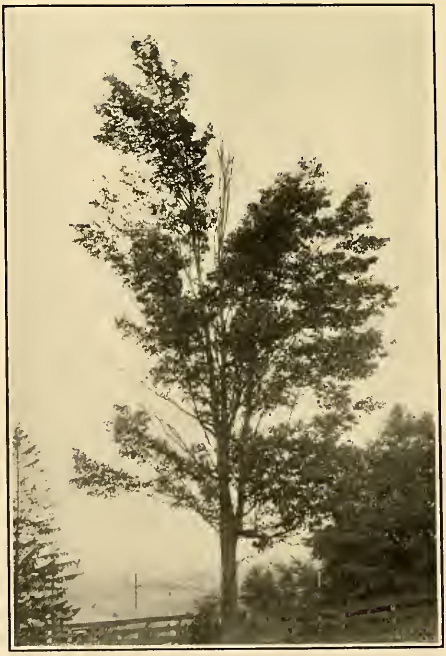

FIG. 2. — Showing maple with staghead effect.

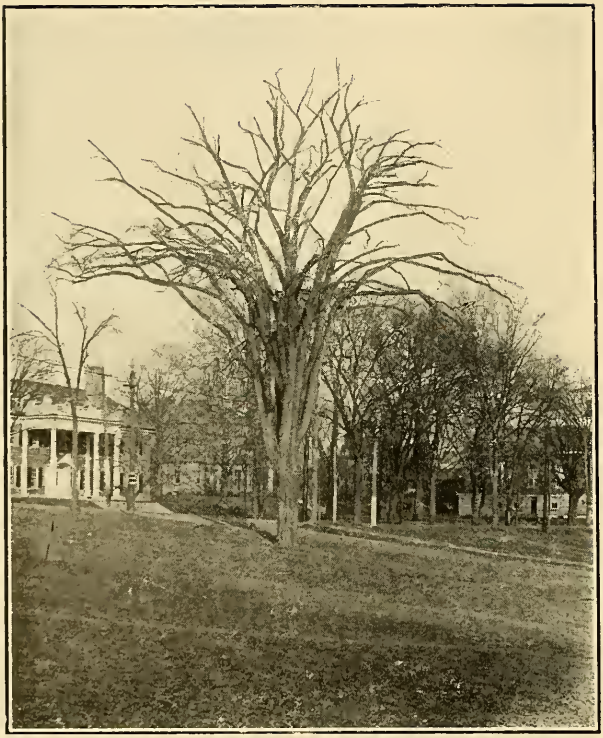

Fig. 3.—Showing elm tree slowly dying, with staghead effect. Note dead, stubby branches at the top.

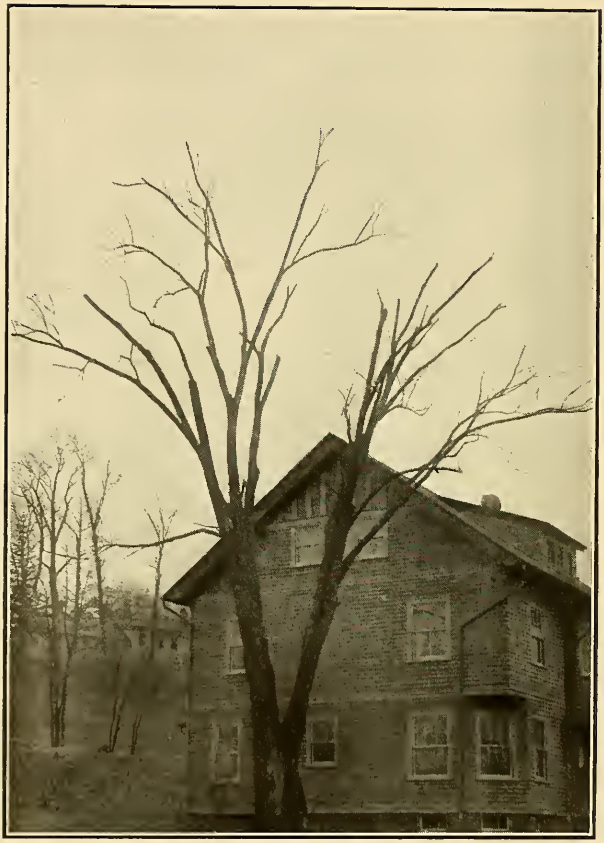

FIG. 4.—Showing elm slowly dying, with staghead effect.

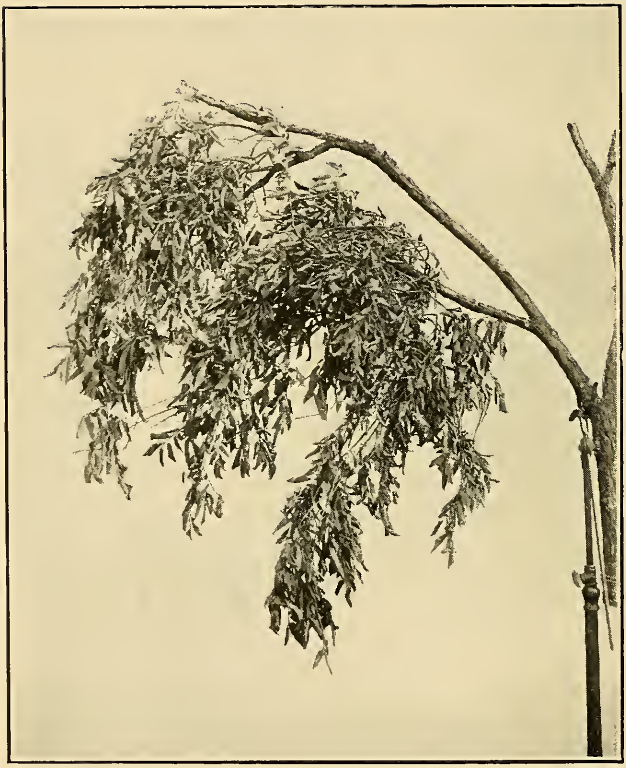

Fig. 5. — Showing elm branch with tufted foliage. A large percentage of the branches on this tree are dead.

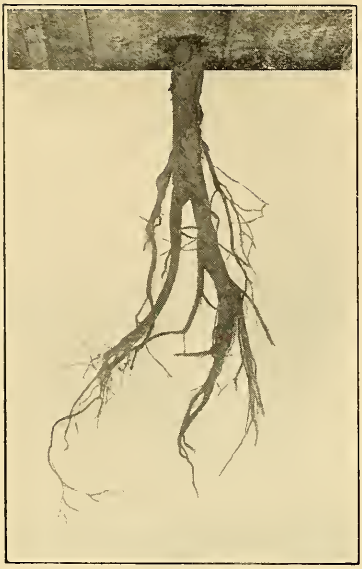

FIG. 6. — Showing winter-killed root from elm tree. Note lack of fine fibrous roots, which have died.

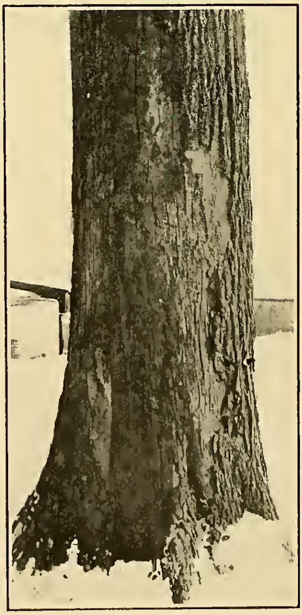

FIG. 7. — Showing elm tree which has lost its outer bark, resulting from injury to cork cambium.

SHADE-TREE TROUBLES.

G. E. STONE.

Staghead and Root Injury.

Many trees since the year 1904 have been showing a characteristic trouble called "staghead." This was particularly noticeable in different degrees of severity on the red maple (*Acer rubrum*) during the summer of 1904, caused by winter killing of roots, etc. In some cases the injury took the form of a scant production of foliage at the top, while in others most of the foliage at the top would not grow to more than one-fourth its natural size (Fig. 1); and in still other cases, and by far the most common, the top of the tree died outright (Fig. 2). In the cases where the foliage was merely thin the trees recovered the following season and have remained in a normal condition since. In others, the foliage at the top would become continually more scant and more limbs affected, until eventually the whole tree would die. Owing to a defective root system a very large number of maples were affected in this way.

During the past two years a large number of trees in the northeastern part of the United States have shown this staghead effect. The trouble appears to have come from the root system, but whether due to winter injury or to the extreme drought which has been common the last five or six years, or to both, is not known at the present time. There are many varieties of shade trees affected in this way at the present time, and this means their ultimate destruction, since those that do not die outright will never recover their tops, and are therefore worthless as specimens of shade trees. This dying back is particularly noticeable on elms, which appear to have been affected at the roots for possibly eight years (Figs. 3 and 4). Owing to the different habits of branching, — the rock maple possessing one main leader, while the elm has a number, — their manner of dying back is different from that of maples. In the latter the most direct channel for the conduction of water is usually through a single leader, while in the elm the water is conducted through several leaders. The center of a maple is therefore affected first, but in the case of the elm the trouble may be noticed in some cases on one side of the tree alone, while in others the whole tree suffers. With some trees the terminal twigs and branches die gradually, it requiring from three to six years for the tree to collapse, while again the tree may die very suddenly. Sometimes a great many of the smaller branches and the remaining branches and twigs are characterized by dense (Fig. 5) tufted foliage. The black oak (*Quercus ellipsoidalis*) and the white oak (*Q. alba*) are affected by winter killing in some sections, and an examination of the roots of numerous trees showed them to be in very bad condition (Fig. 6). A principal feature of the dying back of the oak in some localities is the production of clusters of unusually large and abnormal leaves here and there on the twigs and branches — the tufted foliage already mentioned.

A large number of chestnut trees not affected in any way with chestnut blight have the last three or four years developed staghead. While the symptoms of this dying back are not alike in all cases, they are easily distinguished from those caused by other agents such as gas poisoning, etc. In a majority of cases trees showing this staghead effect, whether from drought or winter killing, die gradually, and even when their death is more or less rapid there are few of the symptoms characteristic of gas poisoning. Trees poisoned by gas usually die quickly and disintegrate rapidly; besides, the diagnostic features to be found in the tissues of trees killed by gas are entirely different. When a tree is affected by gas the poisonous constituents are slowly translocated from one part of the tree to the other, and the symptoms of this type of injury may be easily distinguished from that of other types.

A characteristic feature of trees affected with staghead, more conspicuous in slowly dying trees, may be seen in the increase of the heartwood and decrease of the sapwood. A diminution of the water current in the woody tissue appears to be the cause of this transformation. As a consequence of this diminution the wood of the slowly dying trees is very brittle, and the limbs and branches fall off easily. Old trees reaching the end of their grand period of growth usually show the same characteristics, and for this reason they, too, become dangerous. For many years we have observed the falling of limbs and trees, and have noticed that outside, of course, of tempests, ice storms, etc., a large percentage fall when there is no wind and when the atmosphere is unusually quiet, especially during October and November after the leaves have fallen. The exact cause of this we do not know, although it may be associated with some physical or chemical change in the tissues occurring after defoliation. It is known, however, that water, oils and various chemical substances modify the physical properties of the tissue, and the water contents of a tree at different seasons of the year vary, as shown by Clark,[1] from 25 to 70 per cent., and in severe periods of drought the percentage of water may be very low. That this variation may have some influence here is suggested by the behavior of chemically treated paper containing wood fiber. When wet its tensile strength is increased.

INJURY TO CORK CAMBIUM.

A great deal of injury to the roots and other parts of trees occurred from the severe cold of the winter of 1903–04. The death of tissue from winter killing is induced by a variety of causes and conditions, and we shall not attempt to discuss them here except to state that any plant, whether indigenous or introduced, is susceptible to winter injury if the conditions are favorable. But it is not always the case that all the living tissues are injured, since winter killing is often local, and even a single tissue may be affected. Following this unusually cold winter many trees died outright, and we found many elms and some sycamores which had lost their outer bark, apparently because of injury to the cork cambium. Sometimes the bark, cortex and phloem were all injured, but in most cases noticed only the outer bark was involved (Fig. 7). This type of injury would not in most cases be noticeable at first, but gradually the dead outer bark which had remained on the tree for some time would peel off in reddish flakes, finally crumbling into dust. We have observed cases in which all the outer bark of large sycamore trees extending to the cortex had peeled off without causing any particular harm.

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[1] Twenty-second Ann. Rept. Sec'y Mass. State Bd. of Agr., 1874, p. 288.

SUN SCALD.

Sun scald is a quite common type of injury affecting various maples and other trees, — the apple in particular, where it is often associated with canker (*Sphæropsis*). White pines, also, when thinned too freely, will sun scald severely on the trunk. Many shade trees in our State show injury from this cause, the trouble being more common in some localities than in others. In one section of a city in the eastern part of the State we found a short time ago more than 60 per cent. of the maples suffering from sun scald. The scars were invariably on the sunny side of the tree, and more commonly on the southwestern side, where the maximum temperature was usually found.

Sun scald does not usually involve the whole trunk of large trees, but in many cases, particularly small maples, the whole tree will suffer. A few years ago on one street in a comparatively short distance, sixteen maples might have been seen which had died from sun scald, and at one time most of our wild cornels (*Cornus circinata*) suffered severely from this trouble, many of them never recovering. The moose maple, a shade plant, seldom scalds in its native habitat but when timber is removed and the sun allowed to enter, it is affected. This tree is undoubtedly the most sensitive of any to sun scald.

Most cases of sun scald are followed by an outbreak of *Nectria cinnabarina,* as is often the case with winter killing, and unripened wood is more susceptible to the trouble than well-ripened wood. The under branches of unpruned apple trees are especially susceptible to sun scald, while the upper branches, which receive the light, are affected the least.

BLEEDING.

A great many trees suffer from bleeding from different types of injury, such as borers, frost cracks, splitting of the trunk and occasionally linemen's spurs. Often trees filled with cement bleed, the exudation causing an unsightly appearance of the bark. Bleeding to excess is very injurious. Sometimes the death of trees from this cause is sudden, and in other cases the tree will linger, gradually dying back at the top, and eventually collapsing. The exuded sap, known as "slimy flux," usually contains a large number of micro-organisms which give the sap a peculiar odor. Elm trees often show a white streak on the bark caused by some injury resulting in bleeding, and maples are also quite often affected, sometimes going into a slow decline, followed by death from bleeding alone. In one instance we observed a maple of fairly good size which had frost cracked so badly that it did not live for more than five or six weeks, the numerous cracks extending from the top to the bottom of the trunk. These injuries are a difficult class to treat, and at present no satisfactory method is known.

Injuries from Snow.

Vegetation is occasionally injured by snow. The leaves of coniferous trees — *Pinus Strobus,* for example — are sometimes affected, and the needles on the lower limbs of small pines which have been covered by snowbanks in the spring turn brown and die. But injury from snow is not very common, and has never been known to cause serious harm.

Earth Fillings.

The remodeling and regrading of streets, lawns, etc., often necessitate filling in around trees. These earth fillings are usually fatal to trees, due no doubt as often to the effects of the earth on the bark as to the lack of air to the roots from the deep covering of the soil. We have seen trees growing on a bank with one side of the root system and part of the trunk covered with soil. Those parts covered with soil gradually died, and finally the whole tree collapsed. The maximum depth of soil around the trunk was not more than 8 inches, but the roots were covered for 18 to 20 inches. The soil used for refilling was of a fine texture, — undoubtedly more injurious than a loose-textured soil would have been. In this case the death of the trees was caused by too close contact of the soil with the bark. When a stone wall is first built around the tree at sufficient distance to allow for future growth, to keep the soil away from the trunk, trees filled in to a height of 5 or 6 feet have been known to survive for many years.

Some trees are undoubtedly more easily injured by earth fillings than others, but building a wall around them to keep the dirt from the trunk, or even the use of cobble stones, brick or coarse gravel close to the trunk, tends to prevent injury. Banking soil for even a few inches around young trees sometimes causes injury. In the case of a young orchard which we observed a few years ago soil was piled up 3 or 4 inches around the trunks of some of the trees for the purpose of protection, but in nearly all instances the tissue underneath was dead, while the trees not treated in this way were all alive.

There are many instances where trees which have been buried partly up the trunk threw out a new root system nearer the surface of the soil. The tree shown in Fig. 8 had been filled in with soil to a depth of 4 feet thirty-five years ago, and in removing the tree it was found that the old stump and roots were all decayed, but the new surface roots had proved sufficient to support the tree.

Exposure of Roots.

Occasional injury occurs to the large roots of trees from regrading and other causes. A few years ago we had occasion to examine a large number of hickory trees (*Carya alba*) located on a country estate which had been injured quite seriously, apparently from sun scald. They had been growing for many years under natural conditions and were fairly vigorous, but during the construction of a large house, and the regrading of the ground, many of the roots — particularly the buttresses — had become exposed. In every case where the soil was taken from the base of the tree and the roots were exposed, the tissue was all sun scalded, but the tissue on the underside of these roots was perfectly normal. In some cases this caused the death of the trees.

It is sometimes possible to expose the larger roots of trees without doing any harm, but at other times sun scald will

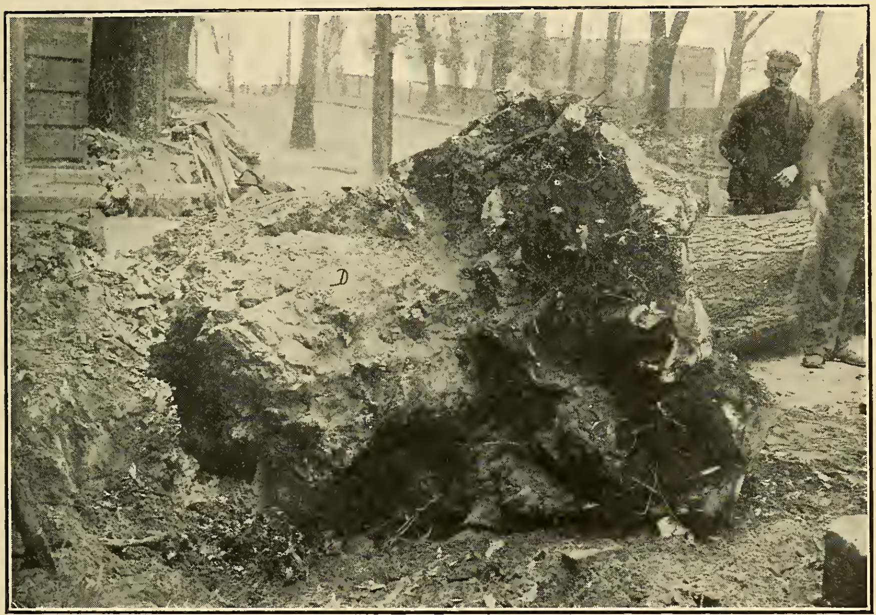

FIG. 8. — Trunk of an elm tree showing old trunk and new formation of roots. Photo from W. F. Gale, City Forester, Springfield, Mass.

result. In cities where the streets are constantly being regraded, the surfaces of the larger roots may often be found exposed, but in perfectly normal condition.

INJURIES FROM VARIOUS TREATMENTS.

We have at different times had occasion to observe injuries to shade trees brought about by various causes, in many cases resulting from treatment applied by careless or ignorant persons. The present widespread treatment of various pests, as might be expected, has made necessary the testing of different remedies, some of which have proved to be more injurious than the pests themselves. These materials have not only been used by careful people trained in the use of different methods for controlling insects and fungi, but by others who are reckless to the point of seeming to delight in taking chances.

Oil. — Many different oils have been used for spraying insect pests, some of which have proved reliable and others injurious. Kerosene oil can be used on some plants under certain conditions without causing injury, while in other cases it will kill them. A few years ago there was placed on the market a spraying device for the mechanical mixing of kerosene and water in different proportions, but when these materials are mixed mechanically they usually separate, and they have been responsible for the death of many trees. The oil soaks into the bark and often reaches the cambium and sapwood, destroying the tissue; and we have seen quite a few shade trees killed by spraying with kerosene and water to exterminate wooley aphis. In some cases every part of the tree touched by the kerosene was injured, while in others the injury was only local, a more commonly noticed condition on thick-bark trees, while the former case was invariably restricted to trees with thin bark. The bark of trees killed by the use of kerosene presents a different appearance and develops usually a different type of fungous flora from the bark of trees dying from other causes; besides, traces of the oil, which remain on the tree for a long time, can be detected by the sense of smell. A fair diagnosis of this type of injury may be made from specimens of the bark, but when there are comparatively slight local injuries it is best to examine the tree *in situ.* Even slight traces of oil may be detected by removing small portions of the outer bark on the sunny side of the tree, the sun's heat causing a slight volatilization and perceptible odor.

Gas oil, a heavy oil used in the manufacture of water gas, is very injurious to trees when used as a spray. A few years ago several hundred shade trees were severely injured in one of our eastern cities by spraying the trunks with this oil to kill clusters of gypsy moth eggs, it being used without any knowledge of its adaptability to this purpose (Fig. 9). The oil quickly soaked into the bark, cortical tissue and cambium, and in some cases extended into the sapwood for one-half to three-fourths of an inch. This injury occurred even on trees with fairly thick bark, killing all the living tissue wherever the oil was applied. While in some instances the trees did not show extensive injury, in others the trunks were 50 to 90 per cent. girdled, and many of the trees died from complete girdling. The most striking feature of this case was the ability of the trees to produce perfect foliage even after serious injury had been incurred. One tree was examined whose trunk was girdled for a height of 15 to 20 feet, but this tree persisted in producing foliage for two years after the bark had fallen off. An explanation of this remarkable case consists in the fact that the heavy oil soaking into the sapwood prevented it from checking or cracking, therefore the supply of water from the roots was uninterrupted. The trees treated were elms, different species of maples, etc. The presence of oil in the sapwood in the cases cited above was of the greatest aid in preventing cracking and in helping to maintain the transpiration current and a full crop of foliage, and this bears out the recommendation that tree wounds should be painted or treated in some way very soon after they are formed to prevent cracking. It is sometimes necessary to scrape the wound before applying the paint.

Ordinary house paint, although a crude enough treatment, has sometimes been used by ignorant persons on smooth-bark trees, with of course resultant injury.

Occasionally commercial oils used for spraying fruit trees for the San José scale cause local injury, and some shade trees have been known to be affected by their use.

Oils and other materials to keep down the dust in roadbeds

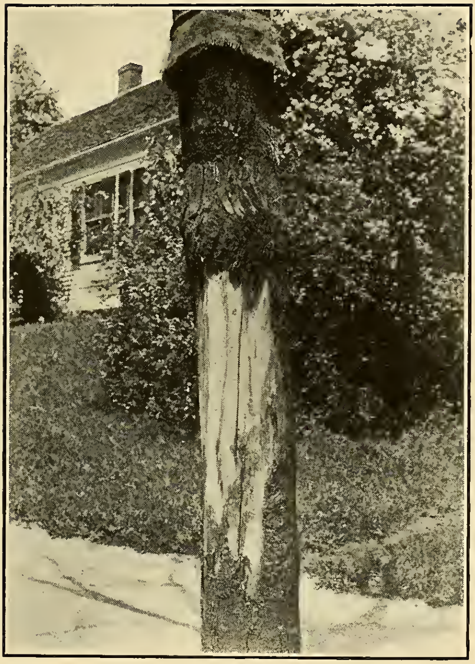

FIG. 9. — Showing effects of spraying heavy oil on trees. The oil penetrated the bark and killed the tissue.

are now much in use, and we have observed some injury from this source, when the trees were located close to the highway and the buttresses of the roots were exposed. The roots are much more susceptible to injury from various causes than are the trunks as they are not so well protected by bark, and when oil sprinkled on a roadbed touches some of the exposed roots it kills the tissue. Particles of dust from oiled roads which sometimes alight on the foliage of trees are said to cause injury, but this type of injury is rare with us. Whether the oil ever extends deeply enough into the roadbeds to reach the root system of trees is not known as yet, but if it does it may cause serious injury. Neither are there specific cases of injury to the roots of trees by the dripping of oil and gasoline from automobiles, although if this leakage were sufficient it might reach the roots and cause injury. Not long ago, however, our attention was called to a tree supposed to have been killed by gasoline leakage from a near-by garage.

Creosote. — This material is used extensively on trees for disinfecting cavities, and mixed with lampblack for painting gypsy moth egg clusters. It does not appear to penetrate to any great extent when combined with lampblack. We have examined a great many trees to discover injuries from its use with no success except in the case of linden roots which had been exposed by regrading, where the underlying tissue was injured. But such instances are rare and the injury purely local in character.

In one case a combination of creosote and naphtha applied to a large number of trees for the destruction of gypsy moth caterpillars appeared to soak into the outer bark, apparently killing the cork cambium, which later resulted in a disintegration of the tissue. Whether these substances did further injury to the tree we were not able to learn.

Coal Tar. — Coal tar is much used for painting wounds and scars caused by pruning, and sometimes injures delicate tissue when first applied. The injury, though, is not serious, as shown by the fact that various saprophytic fungi have been applied over dead, punky wood. Therefore after coal tar has been on for some time it is evidently not injurious to even delicate tissue.

Banding Substances. — A study of the effects of different banding substances has been published in the 1907 report of the Hatch Experiment Station. The writer has since then had an opportunity to study these effects quite extensively. Tanglefoot appears to be the only substance that does not cause injury when applied directly to the bark, *i.e.,* when tarred or other heavy paper is not used. Many laboratory samples of substances resembling tanglefoot have been made up, but in only one instance have any of these materials resembled tanglefoot in practically all its properties; at least, among those which have come to our notice. While the injuries from banding substances have been quite pronounced, practically all of the substances causing injury have now been discarded.

An examination of many trees treated with the so-called tanglefoot has revealed only one case of girdling, and even in this case we were not able to obtain any clue to the manufacturer of the particular material causing the injury. This substance, although resembling tanglefoot, may have been one of its many imitations, some of which are known to cause injury. The only other case of injury from tanglefoot was where it had been applied to the trunk at the same place for a number of years. The oil seemed to penetrate the outer bark to some extent, affecting the texture of the bark; but this injury is not serious, so far as we have observed, and can be prevented by changing the location of the band occasionally. We have never noticed any injury from the use of tanglefoot to the cortical tissue or cambium located just underneath the bark. Our previous experiments show that the most delicate tissue was not injured when it was applied to various plants. But injury was noticed to smooth-bark trees when other banding substances were applied even on tarred paper. Tarred paper alone is capable of injuring the bark of some trees, and the injury mentioned above may have been caused in this way.

Salt. — Salt used on sidewalks, in gutters and on trolley lines in winter has been known to cause injury to the root systems of trees. In one instance we noted injury to several small maples growing near a sidewalk and gutter which had been treated heavily with salt. In one or two other cases where salt had been used extensively on trolley tracks injury to trees was suspected.

Other Injurious Factors. — Arsenate of soda, potassium cyanide and other chemicals are extremely poisonous to trees, and when placed in holes bored in the tree the two first named will soon cause death. Since arsenate of soda is often used as a weed killer, it is recommended that care be taken in applying it around the feeding roots of trees.

A quite common opinion among line-men is to the effect that copper spikes driven into trees will kill them, but a small maple so treated by us a few years ago showed no abnormal symptoms.

The foliage of different trees is often injured by spraying with various fungicides and insecticides. It is well known that plum and peach foliage is quite susceptible to this type of injury, and even the leaves of maples and other trees may be injured by arsenate of lead. The extent of the injury depends not only on the nature of the spraying solution or mixture used, but also on the condition of the foliage sprayed. We have observed injury to maples from the use of 12 pounds of arsenate of lead to 100 gallons of water, and Paris green, owing to its present-day uncertain composition, often burns foliage.

Burning insect nests with torches, although a common practice, is a bad one, and invariably causes injury. Serious harm often results from burning leaves and grass around trees; and the roots of forest trees, which are often close to the ground, are sometimes injured by burning the underbrush.

In conclusion it might be said that in any treatment of trees one should always have before him some definite object; he should leave strictly alone the numerous irrational methods constantly being advocated, and apply to them first the measuring stick of common sense.

EXPERIMENTS RELATING TO THE CONTROL OF POTATO SCAB.

G. E. STONE AND G. H. CHAPMAN.

Early ideas concerning the nature and cause of potato scab in Europe and America varied quite widely, and the history of the study of this disease and the discovery and isolation of the specific organism causing it, together with the discovery of measures for its control, afford a brilliant example of the efficiency of modern pathological investigations. But it is not our intent to give a detailed account of the history of this disease as that has already been done by Dr. J. C. Arthur,[1] Dr. J. E. Humphrey,[2] Dr. R. Thaxter,[3] and particularly Prof. H. L. Bolley,[4] who has given a very full bibliography of European and American investigators.

From the earliest times many theories have been advanced by different observers relative to the cause of potato scab. Some of these early investigators attribute the cause of the disease to different organisms, while others associate the disease with innumerable factors, such as soil, moisture, etc. Dr. J. C. Arthur [5] appears to have been the first American pathologist to study the causes of potato scab. His early experiments were to determine the influence of various factors which some of the older observers regarded as having a bearing on the cause of the disease. In co-operation with Dr. C. A. Goessmann, however, Dr. J. E. Humphrey was working on the disease along the same lines at practically the same time, although his first publication appeared later than that of Dr. Arthur. On Aug. 26, 1890, Prof. H. L. Bolley, then with the Purdue Agricultural Experiment Station, Ind., read a paper before the American Association for the Advancement of Science on potato scab, which was published in the September and October number of "Agricultural Science" the same year, and he established that "(1) the disease is of parasitic origin; that (2) it is for the most part conveyed to the growing crop by infection from the tubers used as seed; that (3) much of the so-called 'smooth seed' is in reality infested with the germs of the disease; and that (4) planting seed tubers free from disease germs gives a crop practically without scab." [1]

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[1] J. C. Arthur, 6th Ann. Rept. N. Y. (Geneva) Agr. Exp. Station, 1888, pp. 344–347.

[2] J. E. Humphrey, 6th Ann. Rept. Mass. Exp. Station, 1888, pp. 131–139; also 7th Ann. Rept., 1889, pp. 214–223, and 8th Ann. Rept., 1890, pp. 216–230.

[3] R. Thaxter, Ann. Rept. Conn. Agr. Exp. Station, 1890, pp. 81–95; also 1891, pp. 153–160.

[4] Agr. Science, 1890, Vol. IV., pp. 243–256; also pp. 277–287.

[5] J. C. Arthur, Bul. 56, Purdue Univ. Agr. Exp. Station, 1895.

His researches and experiments proved to be a great step in advance. While he apparently did not discover the true nature of the organism he paved the way for investigations on the prevention of the disease.[2]

The results of Dr. R. Thaxter's investigations, which were carried on in 1890, were read before the Association of Agricultural Colleges and Experiment Stations November, 1890, and later were published in a report of the Connecticut Experiment Station. His work largely confirmed that of Professor Bolley. He isolated and cultured an organism with which he was able repeatedly to successfully inoculate potatoes and produce the typical scab, although the organism was different from that described by Professor Bolley. It should be noticed that both Professor Bolley and Dr. Thaxter were working on the same lines unknown to each other, and made their results public at nearly the same time, each having arrived at similar conclusions as to the cause of the scab. The organism which Dr. Thaxter isolated was not a bacterium but a low form of fungus possessing more or less indefinite relationships. He later named this, *Oöspora scabies*. Although this organism has been isolated and studied by only a few other pathologists, it is generally recognized that it is the principal if not the only organism associated with the scab. It would not be at all unlikely that the bacterium which Professor Bolley isolated is capable of producing a form of scab; nevertheless, from the viewpoint of treatment and remedies it matters little whether there is one organism or two associated with the disease. In either case remedies are based on the same principle, *i.e.,* the disease is caused by a pathogenic organism and is infectious.

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[1] J. C. Arthur, Bul. 56, Purdue Univ. Agr. Exp. Station, 1895.

[2] Professor Bolley was thoroughly convinced that potato scab was caused by a pathogenic organism, and from the first made use of corrosive sublimate in his experiments. He was unfortunate in having very poor material to work with, and informs me that the soil was badly contaminated with the scab and bacteria. Dr. Thaxter observed the fungus growing on the surface of the potato, but Professor Bolley failed to find this, although he found plenty of bacteria.

Professor Bolley [1] later developed a method for preventing the scab which has proved quite effective, at least under certain conditions. This method consists in soaking the seed potatoes in a solution of corrosive sublimate, 23 ounces to 15 gallons, for a period of one and one-half hours. This is to destroy the germs on the seed potatoes, and when this treatment is applied with such necessary precautions as the avoidance of stable manures, etc., it has proved effective, at least when the organisms are not especially abundant in the soil. Experiments with corrosive sublimate were also carried on for three years by Dr. J. C. Arthur,[2] and in the meantime both Professor Bolley and Dr. Arthur were experimenting with formalin, Professor Bolley [3] as a remedy for the smut of wheat, oats and barley, and Professor Arthur as a remedy for the scab. Professor Arthur [4] later published his experiments with the use of formalin as a preventive of potato scab. He shows that formalin (40 per cent. solution), used at the rate of 8 ounces to 10 gallons of water, is effective and equal to corrosive sublimate, besides possessing fewer disadvantages in handling. Corrosive sublimate and formalin have now been in use for many years as a preventive of potato scab, and both have been the means of greatly reducing the disease. As they are designed to kill the organisms on the surface of the tuber and not those in the soil it is always necessary to use other measures to accompany the treatment with the chemicals. Dr. Thaxter from the first recognized the necessity of using clean seed potatoes and the avoidance of stable manures.

Dr. B. D. Halsted [5] has experimented with various substances for the control of potato scab, and he has reported especially favorable results from the use of flowers of sulfur applied to the soil. He maintains that it not only proved to be the best remedy for the scab but had a wholsome effect on the soil. Dr. Arthur, on the other hand, found sulfur unpromising and discontinued experiments with it. His experience with sulfur was corroborated by Dr. H. J. Wheeler [1] and Mr. G. M. Tucker, who experimented to quite an extent with sulfur and various fertilizers. They found that when sulfur was freely mixed with soil badly contaminated with scab it had no appreciable effect in controlling the disease, and was practically a failure. They found, also, that stable manure of all kinds, wood ashes, air slaked or caustic lime, carbonate of soda, potash, lime and magnesia favored the scab. They obtained a scabless potato with calcium chloride or land plaster (gypsum), and when fertilizers were used without any free lime compounds no scab occurred. They further observed that the marked acidity of the soil or the absence of carbonates was unfavorable to scab. They maintain that when the soil is favorable to the development of scab, or when badly contaminated, the corrosive sublimate treatment is entirely useless as a preventive. The results of Wheeler and Tucker's experiments are in accord with conditions which we have observed in Massachusetts for many years. The presence of carbonates in the soil will increase scab from 2 or 3 per cent. to practically 100 per cent. in a relatively short time, and the use of clean seed, or their treatment with corrosive sublimate or formalin according to the formulas recommended under these conditions, is of little value. On the other hand, when soils are unfavorable for the development of the scab and are only slightly contaminated, formalin and corrosive sublimate are very effective and have been of great value as preventives of this disease.

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[1] H. L. Bolley, Bul. 4, North Dakota Agr. Exp. Station, 1891; also Bul. 9, 1893, pp. 19–95.

[2] J. C. Arthur, Bul. 56, Purdue Univ. Agr. Exp. Station (Ind.), 1895.

[3] H. L. Bolley, Bul. 19, N. D. Agr. Exp. Station, 1895; also Bul. 27, 1897, and Bul. 37, 1899.

[4] J. C. Arthur, Bul. 65, Purdue Univ. Agr. Exp. Station (Ind.), 1897.

[5] B. D. Halsted, Bul. 112, N. J. Agr. Exp. Station, 1895; also Bul. 120, N. J. Agr. Exp. Station, 1897.

Experiments with Various Chemicals for the Prevention of Potato Scab.

In the spring of 1908, as a result of much local complaint relative to potato scab and methods of eradication from infested soil, it was thought that it might be possible to treat the soil with certain chemicals and in this way eradicate the trouble.

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[1] H. J. Wheeler and G. M. Tucker, Bul. 40, R. I. Agr. Exp. Station Rept. 1896, pp. 80–96.

Wheeler and Tucker have made many observations on the influence of fertilizers on potato scab. They found that such substances as common salt, oxalic acid, calcium chloride and land plaster (gypsum) did not increase the scab, and in some instances appeared to lessen it. Various fungicides and chemical substances have been tried by Arthur and others, some of which were applied to the soil and others to the seed tubers. Many of these have been found beneficial in checking the scab, but none appear to be as effective as corrosive sublimate and formaldehyde.

In our experiments arbitrary substances were taken, some of which under proper conditions were known to have a fungicidal action.

It was thought useless to use fertilizers in excess as a means to the end, as it had been shown that fertilizers as a rule have little or no effect on the increase or decrease of the scab in land, with one exception. It was noted repeatedly on experimental plots at the station that where potash was applied in the form of the carbonate the relative amount of scab was always increased.[1]

The experiments described in the following pages were carried on in circular, lined tiles with a diameter of 23 inches, with therefore an area of approximately 424 square inches, or a soil area of a little less than 3 square feet.

In the application of the substances no attempt was made to bring the quantities used to an amount that would make them commercially valuable, and up to the present time this policy has been carried out, as the idea primarily was to find some substance which would be beneficial in the eradication of the scab, and then work the amount down to a commercial scale.

The potatoes used in all the experiments were free from scab, but were all treated with formalin (1–250) to kill any spores of scab fungus which might be present. After the tubers were dried they were planted in the tiles which contained equal amounts of soil known to be badly infected with the scab fungus.

In the experiments carried on in 1908 the substances and amounts used are shown in Table I. Where liquids were used, the amount of water in indicated proportions was added.

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[1] Influence of Various Potash Salts on Potato Scab, 13th Ann. Rept., Mass. Agr. Exp. Station, 1907, pp. 39 and 133.

Where solid substances were used, the substance was mixed thoroughly with the top 4 inches of soil.

In the following table a check tile was used alternately with a treated tile, and as the amount of scab on the potatoes in all the check tiles was practically the same, the checks are omitted: —

TABLE I. — *Plan of Potato Scab Experiments, 1908.*

Pot Number.	SUBSTANCE USED.	Amount used.
1	Formalin, 1–100,	114 cubic centimeters.
3	Formalin, 1–200,	57 cubic centimeters.
5	Formalin, 1–300,	38 cubic centimeters.
7	Formalin, 1–400,	28.5 cubic centimeters.
9	Potassium permanganate, 1–100,	57 grams.
11	Potassium permanganate, 1–300,	38 grams.
13	Potassium permanganate, 1–400,	28.5 grams.
15	Potassium permanganate, 1–500,	23 grams.
17	Sulfuric acid, 1–200,	57 cubic centimeters.
19	Sulfuric acid, 1–400,	28.5 cubic centimeters.
21	Sulfuric acid, 1–600,	19 cubic centimeters.
23	Sulfuric acid, 1–800,	14.25 cubic centimeters.
25	Acid phosphate,	57 grams.
27	Acid phosphate,	38 grams.
29	Acid phosphate,	28.5 grams.

The potatoes were cultivated in the usual way and allowed to mature. When dug the yield was taken of each pot separately, and the relative amount of scab as compared with the corresponding check tile, but in most cases the yield and amount of scab present closely approximated the check, so nothing of value was obtained from this experiment, as a whole. It was noted, however, that the tiles treated with formaldehyde or formalin were somewhat freer from scab individually; also in the case of the permanganate very little yield was obtained, but the usual amount of scab was present. The sulfuric acid treatment showed possible beneficial effects, but the yield was so small that no accurate comparison could be made.

The experiments, on the whole, were very unsatisfactory, and no deductions of any importance could be made.

The experiments of the season of 1909 were planned in the same manner, but owing to other causes over which we had no control the crop was lost before the examination could be made.

In 1910 the experiment as planned and carried out was as follows: —

TABLE II. — *Plan of Potato Scab Experiments, 1910.*

Pot Number.	Substance used.	Amount used.
1	Formalin, 1-100,	114 cubic centimeters.
3	Formalin, 1-200,	57 cubic centimeters.
5	Formalin, 1-300,	38 cubic centimeters.
7	Formalin, 1-400,	28.5 cubic centimeters.
9	Potassium permanganate, 1-100,	57 grams.
11	Potassium permanganate, 1-300,	38 grams.
13	Potassium permanganate, 1-400,	28.5 grams.
15	Potassium permanganate, 1-500,	23 grams.
17	Sulfuric acid, 1-200,	57 cubic centimeters.
19	Sulfuric acid, 1-400,	28.5 cubic centimeters.
21	Sulfuric acid, 1-600,	19 cubic centimeters.
23	Sulfuric acid, 1-800,	14.2 cubic centimeters.
25	Sulfur,	50 grams.
27	Sulfur,	100 grams.
29	Sulfur,	200 grams.

Upon examination it was found that the check pots were practically all scabby. This was taken as a basis of 100 per cent. scab, and the results from the various treatments estimated in relation to this basis.

Pots Nos. 1, 3, 5 and 7, which were treated with formalin, showed the presence of scab as follows: in pot No. 1 the potatoes had only 10 per cent. scab, as against 30 per cent for pot No. 3, 24 per cent. for pot No. 5, and 70 per cent. for pot No. 7.

In the pots treated with potassium permanganate no yield was obtained except in one case and one check, and here the potatoes were about 50 per cent. scabby in both cases.

In the sulfuric acid treatment no yields of potatoes were obtained except in the check tile, and they averaged 60 per cent. scab.

In the sulfur treatment the treated pots in general showed a slight gain over the untreated or check pots, but not enough to warrant definite favorable conclusions being drawn.

The plans for the experiments in the season of 1911 were changed somewhat, and other chemicals substituted for some that were previously used. This was the result of the non-action or the negative results obtained from some of the substances used. The whole method of choice of substances was of course haphazard, as no foundation for the use of some was warranted.

In 1911 the chemicals used were as follows, and the only old one to be used was formalin. Table III. gives the plan of the year's experiments: —

TABLE III. — *Plan of Potato Scab Experiments, 1911.*

Pot Number.	SUBSTANCE USED.	Amount used.
1	Steam-sterilized,	– –
3	Steam-sterilized,	– –
5	Steam-sterilized,	– –
6	Steam-sterilized,	– –
7	By-product A,	5 grams (dry).
9	By-product A,	10 grams (dry).
10	By-product A,	10 grams (wet).
12	By-product A,	15 grams (dry).
13	By-product A,	25 grams (dry).
15	By-product A,	40 grams (dry).
16	K permanganate-formalin,	100 cubic centimeters, 6 grams.
18	K permanganate-formalin,	25 cubic centimeters, 10 grams.
19	K permanganate-formalin,	40 cubic centimeters, 16 grams.
21	K permanganate-formalin,	60 cubic centimeters, 24 grams.
22	Copper sulfate, 1–1,000,	– –
24	Copper sulfate (1 gallon), 1–10,000,	– –
26	Carbon bisulfid,	15 cubic centimeters.
27	Carbon bisulfid,	25 cubic centimeters.
29	Carbon bisulfid,	40 cubic centimeters.

In the first series, that of the steam-sterilized, it is noticed that a fair yield of potatoes was obtained, and the amount of scab on the check and treated tiles was as follows: —

	Per Cent Scab.		Per Cent Scab.
Check,	40	Steam-sterilized soil,	30
Check,	18	Steam-sterilized soil,	41
Check,	30	Steam-sterilized soil,	23
Average,	29	Average,	31

These results surely do not show much benefit from sterilization, and on the whole the amount of scab seemed to increase with the sterilization. The reason for this is not apparent, but may be explained in different ways. In all probability sterilizing the soil in open boxes by heating the soil to 210° or 212° F. was not sufficient to kill the germs of scab. It seems hardly probable that if the organisms had been killed by sterilizing, the soil in the pots could have been contaminated to this extent, or that the seed after being treated with formaldehyde could have been the cause of this.

In the second series a manufacturer's by-product was used, which for the present we will call by-product A. This was applied in different amounts and scattered in the soil both in the powder form and as a paste mixed with water. The three checks averaged 44 per cent. scab, and the treated tiles averaged 30 per cent. scab, with the lowest amount of scab present in the tile treated with the smallest amount of the by-product A. On the whole, this substance seemed to have some beneficial action, although apparently there were discrepancies in the comparative amounts of scab present in relation to the amounts of the substance used.

The next series, made up of gaseous formaldehyde treatment by the reaction of potassium permanganate on formaldehyde, gave no results except in one or two instances, and then the yield was very small and in some cases none at all.

The series of tiles treated with copper sulfate showed that this substance might have a beneficial action in strengths up to 1–10,000, but there was the same amount of scab on the tile treated with copper sulfate, 1–1,000, as there was on the checks.

The yield was small, however, both on the treated tiles and the checks.

The series treated with carbon bisulfid showed some results, the check tiles averaging 50 per cent. scab and the treated tiles showing an average of 20 per cent.

It can be seen that this year's results are showing some improvement over those of preceding years, and by elimination only the most useful compounds are to be used hereafter, with perhaps one or two additions.

TABLE IV. — *Plan of Potato Scab Experiments, 1912.*[1]

Pot Number.	SUBSTANCE USED.	Amount used.
1	By-product A, ...	100 grams (dry).
2	By-product A, ...	300 grams (dry).
3	By-product A, ...	500 grams (dry).
5	By-product A, ...	100 grams (wet).
6	By-product A, ...	200 grams (wet).
7	By-product A, ...	300 grams (wet).
9	Sulfur, ...	50 grams (wet).
10	Sulfur, ...	100 grams.
11	Sulfur, ...	200 grams.
13	Naphthalene, ...	50 grams.
16	Steam-sterilized, ...	– –
17	Steam-sterilized, ...	– –
18	Steam-sterilized, ...	– –
20	Formalin, 1-100, ...	– –
21	Formalin, 1-200, ...	– –
22	Formalin, 1-300, ...	– –
23	Formalin, 1-400, ...	– –
25	Carbon bisulfid, ...	15 cubic centimeters.
26	Carbon bisulfid, ...	25 cubic centimeters.
27	Carbon bisulfid, ...	40 cubic centimeters.
29	Nicine, ...	100 grams.
30	Nicine, ...	200 grams.

[1] Numbers omitted were used as check tile. Potatoes treated exactly as in preceding experiments.

In 1912 the experiments were carried on in a similar manner, but for the most part chemical solids were used, with the exception of the formalin treatment, which remained the same as the preceding years.

The by-product A treatment showed good results, especially when applied dry in 500-gram amounts to the pot area. Even in smaller quantities a decided benefit seemed to be obtained, as can be seen from the following summary: —

SUBSTANCE USED.	Amount used, Dry (Grams).	Per Cent.	Amount used, Wet (Grams).	Per Cent.
By-product A,	100	90	100	50
By-product A,	300	40	200	60
By-product A,	500	2	300	50
Check,	–	90	–	75

Apparently this substance has a good effect. The yield of tubers was in all cases good. If the substance were applied at this rate (500 grams to 3 square feet) it would mean about 7 tons to the acre, but it may be shown that a smaller quantity would be sufficient. Much more work is necessary before any definite opinion can be advanced as to the actual worth of the substance.

The sulfur treatment showed slightly beneficial results, the different tiles and check showing the scab present in the following amounts: —

Sulfur, 50 grams,	70 per cent. scab.
Sulfur, 100 grams,	50 per cent. scab.
Sulfur, 200 grams,	60 per cent. scab.
Check,	85 per cent. scab.

The yield of tubers was good in the case of the sulfur treatment.

The naphthalene treatment showed no results, with very little yield of tubers.

The steam-sterilized tiles, sterilized to a depth of 6 inches, and corresponding check showed scab present in the following amounts: —

Steam-sterilized soil (*a*),	60 per cent. scab.
Steam-sterilized soil (*b*),	40 per cent. scab.
Steam-sterilized soil (*c*),	30 per cent. scab.
Check,	60 per cent. scab.

The yield of tubers was good in all cases.

The formalin treatment gave varying results, and when used in quantities sufficient to do good would be probably impractical. The results with formalin were as follows: —

Formalin 1–100,	30 per cent. scab.
Formalin 1–200,	40 per cent. scab.
Formalin 1–300,	70 per cent. scab.
Formalin 1–400,	70 per cent. scab.
Check,	75 per cent. scab.

The yield was only fair in these tiles.

The carbon bisulfid treatment gave negative results, as may be seen from the following: —

Carbon bisulfid, 15 cubic centimeters, fair yield, 80 per cent. scab.
Carbon bisulfid, 25 cubic centimeters, poor yield, 3 per cent. scab.
Carbon bisulfid, 40 cubic centimeters, no yield.

The Nicine treatment gave no results that could be interpreted as either beneficial or otherwise.

The experiments for 1913 will be planned from an economic point of view, and if possible the same experiments will be carried out for a series of years, and plots used in addition to the tiles.

In summarizing the results of experiments with potato scab it will be noticed that many of the substances used had little effect in preventing scab, while others seemed to possess some value. Steaming the soil the second year was done somewhat more thoroughly than the first year, but the results, on the whole, were similar, *i.e.*, in all the sterilized plots, 1911–12, there was little evidence of reduction of the scab. Steaming under pressure or for prolonged periods under no pressure would determine once for all whether the scab germs are unusually resistant to heat. The heated soil, however, proved to be beneficial to the crop, as the yield was good under this treatment.

The best yield in 1912 was given by by-product A in dry form, followed by the sulfur treatment, and the by-product A wet treatment and steam heating. The most satisfactory treatment from the yield point of view as well as that of treatment was by-product A, the dry mixture proving superior to the wet. Our experiments with this substance also indicate that any beneficial results from its use are carried over into the next season, since in those plots in which this substance was employed in 1911 the results were noticeable in 1912. The crop obtained by the use of by-product A at the rate of 500 grams to 3 square feet of surface, consisted of the cleanest tubers we have ever observed in a soil which was badly contaminated with scab, and, furthermore, it does not appear in the least to affect the growth or yield (see Fig. 1). The substance appears to act slowly and continuously as a germicide, and may prove even more efficient in the control of other fungi.

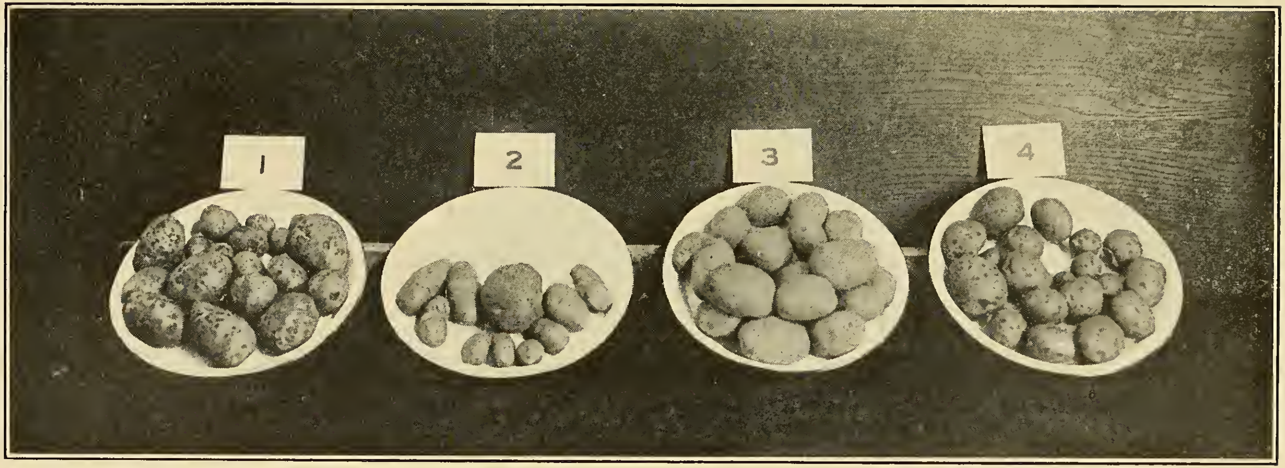

FIG. 1.—Showing treatment of potato scab. All tubers treated with formaldehyde before planting. No. 1, treated with 100 grams of by-product A; No. 2, treated with 300 grams of by-product A; No. 3, treated with 500 grams of by-product A; No. 4, treated with check.

AN OUTLINE OF SOME OF THE TOPICS COVERED BY THE DEPARTMENT OF VEGETABLE PHYSIOLOGY AND PATHOLOGY SINCE ITS INCEPTION.

G. E. STONE.

The department of vegetable physiology was established in the State Experiment Station in 1888, and Dr. James E. Humphrey, under the supervision of Dr. C. A. Goessmann, carried on investigations from November, 1888, to 1892, when he resigned. A bibliography of the more important papers published by the department follows: —

Sixth annual report of the State Experiment Station, 1888: potato scab.

Seventh report, 1889: general account of fungi; potato scab; fungous diseases on the station farm; notes on material referred to the department.

Eighth report, 1890: black knot of plum; mildew of cucumbers; brown rot of stone fruits; potato scab; notes on various diseases.

Ninth report, 1891: rotting of lettuce; powdery mildew of the cucumber; various diseases; preventive treatment.

Tenth report, 1892: diseases of the cucumber plant and violet diseases: the black knot of the plum and cherry; grain rusts; various diseases: treatment for powdery mildew. (From 1892, when Dr. Humphrey resigned, until 1895, the pathological work was temporarily discontinued, but in 1895 the department of vegetable physiology and pathology was established and the work has been continued by the writer since that time.)

Eighth annual report of the Hatch Experiment Station, 1895: this contains mainly an outline of work, and brief references to some experiment topics.

Ninth report, 1896: nature of plant diseases; a bacterial disease of the cultivated strawberry (*Micrococcus sp.?*); stem rot of the cultivated aster; leaf spot of decorative plants; leaf spot of Ficus elastica (*Leptostromella elastica* Ell. & Ev.); a leaf spot disease (*Graphiola Phoenicis* Poit) of the date and similar palms; a leaf spot of the begonia;

a so-called black spot disease of the rose (*Pilobolus crystallinus* Tode); a leaf blight or anthracnose of the cucumber (*Colletotrichum Lagenarium* (Pass.) Ell. & Hals.); an unusual outbreak of two rusts,—asparagus rust (*Puccinia asparagi* D. C.) and a late rust of the blackberry (*Chrysomyxa albida* Kühn.); the tomato mildew (*Cladosporium fulvum* Cke.); a chrysanthemum rust; "drop" of lettuce (*Sclerotinia Libertiana* Fckl.); wilt of maple leaves; topburn of lettuce.

Tenth report, 1897: the causes of the failure of the potato crop of 1897; the "drop" of lettuce; the asparagus rust (*Puccinia asparagi* D. C.); the fire blight (*Bacillus amylovorus* (Burr.) DeToni); quince rust (*Gymnosporangium clavipes* C. & P.); brown rot of stone fruits (*Monilia fructigena* Pers.); the chrysanthemum rust (*Puccinia Tanaceti* S.); some leaf blights of native trees; a leaf blight of the sycamore or buttonwood (*Glœosporium nervisequum* (Fckl.) Sacc.); a leaf blight of the butternut (*Glœosporium Juglandis* (Lib.) Mont.); a leaf spot of the chestnut (*Septoria ochroleuca* B. & C.); a leaf spot of the wild black cherry (*Septoria cerasina* Pk.)

Eleventh report, 1898: scope of work; black spot of the maple (*Rhytisma acerinum* (P.) Fr.); oak leaf blight (*Glœosporium nervisequum* (Fckl.) Sacc.); walnut leaf blight (*Glœosporium Juglandis* (Lib.) Mont.); a muskmelon disease; rotting of cabbage; further considerations in regard to the drop in lettuce; the chrysanthemum rust; a new pansy disease; seasonal peculiarities of certain shade trees; overfeeding of plants; the bronzing of rose leaves; cucumber wilt; some difficulties which city shade trees have to contend with.

Twelfth annual report, 1899: aster diseases; the bacterial cucumber wilt; a geranium disease; muskmelon failures; the maple leaf blight (*Phyllosticta acericola* C. & E.); the chrysanthemum rust; some experiments in growing violets in sterilized soil; the relationship existing between the asparagus rust and the physical properties of the soil.

Thirteenth report, 1900: aster diseases; nematode worms; cucumber mildew (*Plasmopara Cubensis* B. & C.); Russian thistle in Massachusetts; influence of chemical solutions upon the germination of seeds.

Fourteenth report, 1901: the dying of cut-leaved birches; the present status of chrysanthemum rust in Massachusetts; the effects of desiccation on soil; melon failures; stem rots and wilt diseases; the present status of the asparagus rust in Massachusetts; sterilization of soil in greenhouses for fungous diseases.

Fifteenth report, 1902: peach leaf curl (*Exoascus deformans* (Berk.) Fckl.); apple leaf spot; sycamore blight (*Glœosporium nervisequum* (Fckl.) Sacc.); strawberry root rot; apple scab (*Fusicladium dendriticum* (Wallr.) Fckl.); cucumber wilt; sweet pea troubles; aster diseases; potato blight (*Phytophthora infestans* (Mont.) DeBarry); cucumber and melon diseases; asparagus rust (*Puccinia asparagi* D. C.); chrysanthemum rust (*Puccinia Chrysanthemi* Roze); the cucumber mildew (*Plasmopara Cubensis* (B. & C.) Humphrey) in Massachusetts; the muskmelon blight; an apple leaf spot; a strawberry disease; plum "yellows;" spraying of linden and elm trees for leaf spot; crops under tent cloth; experiments in heating soils; influence of sterilized soil on seed germination.

Sixteenth report, 1903: influence of current electricity on plant growth; influence of atmospheric electrical potential on plants.

Seventeenth report, 1904: crops as related to weather conditions; testing of seed; the practice of soil sterilization; influence of electrical potential on the growth of plants; some important literature relating to disease of crops not generally believed to be caused by fungi or insects.

Eighteenth report, 1905: downy mildew of tomato (*Phytophthora infestans* DBy.); potato rot (*Phytophthora infestans* DBy.); cucumber and melon blight; sun scald; burning of conifers and evergreens; winter killing; relation between soil aeration and germination and growth; comparison of sterilized loam and subsoil; influence of soil sterilization on seed germination; an application of the copper sulfate treatment; a comparison of the numbers of bacteria in sterilized and unsterilized soils.

Nineteenth report, 1906: outline of work; seed work; prevalence of fungi, etc.; bacterial disease of cucumbers; bacterial disease of lettuce; bacteriosis of geraniums; tobacco troubles; monilia on peach stem; the lime and sulfur mixture as a fungicide; potato-spraying experiments; banding substances for trees; effects of escaping illuminating gas on trees; germination and growth in soils of different texture; texture of Massachusetts soils.

Twentieth report, 1907: outline of the year's work; seed work; seasonal peculiarities; sun scald; sun scorch premature defoliation of trees; asparagus rust; asparagus Fusarium; peony troubles; potato diseases; experiments with fungicides; influence of various potash salts on potato scab (*Oöspora scabies* Thaxter); investigations relating to mosaic disease; some factors which underlie susceptibility and immunity to disease.

Twenty-first report, 1908: brief notes on the weeds of Massachusetts; results of seed separation; examination of onion seeds for fungous spores; bacterial rot of cabbage and cauliflower; crown gall; the preservation of maple syrup; onion rot; onion smut; a disease of the radish; celery crown rot; eel worms (*Heterodera radicicola* (Greef.) Müll.) on lettuce; influence of water on eel worms; influence of lime on eel worms; effects of chemicals on vegetation; substances and methods used in exterminating weeds; seed work; common weed seeds in grass seed and cattle foods.

Twenty-second report, 1909: diseases more or less common to crops during the year; shade tree troubles; malnutrition; calico or mosaic disease of cucumber and melon; notes on the occurrence of fungous spores on onion seed; spraying injuries; control of certain greenhouse diseases; damping-off fungi; spraying experiments with calcium benzoate; seed purity work, 1909, seed germination and separation; sun scorch on the pine.

Twenty-third report, 1910: diseases more or less common during the year; seed work, 1910; an outbreak of rusts; sweet pea troubles; a spinach disease new to Massachusetts; condition of fruit trees in general; Fusarium disease of cucumbers and other plants; crown gall; chestnut disease (*Diaporthe parasitica* Murrill); shade tree troubles; the spraying of trees; a new type of spray nozzle; the clogging of drain tile by roots; experiments relating to the prevention of the clogging of drain tile by roots; abnormalities of stump growths; peach and plum troubles.

Twenty-fourth report, 1911: diseases more or less common during the year; seed work for the year 1911; do we need a seed law in Massachusetts; rust on Vinca; bronzing of maple leaves; a notable elm tree; frost cracks; some observations on the growth of elm trees; coarse nozzle versus mist nozzle spraying; a new method for the approximate mechanical analysis of soils; the present status of soil sterilization; influence of soil decoctions from sterilized and unsterilized soils upon bacterial growth; the effects of positive and negative electrical charges on seeds and seedlings; electrical resistance of trees; experiments with rose soils.

List of Bulletins issued by the Department of Vegetable Physiology and Pathology.[1]

Electro-Germination, Asa S. Kinney, Bul. No. 43, 1897.
Nematode Worms, G. E. Stone, R. E. Smith, Bul. No. 55, 1898.
Asparagus Rust, G. E. Stone, R. E. Smith, Bul. No. 61, 1899.
Rotting of Greenhouse Lettuce, G. E. Stone, R. E. Smith, Bul. No. 69, 1900.
Growing China Asters, R. E. Smith, Bul. No. 79, 1902.
Cucumbers under Glass, G. E. Stone, Bul. No. 87, 1903.
Fungicides and Insecticides,[2] G. E. Stone, H. T. Fernald, S. T. Maynard, Bul. No. 80, 1902.
Injuries to Shade Trees from Electricity, G. E. Stone, Bul. No. 91, 1903.
Fungicides and Insecticides,[2] G. E. Stone, H. T. Fernald, F. A. Waugh, Bul. No. 96, 1904.
Tomatoes under Glass, G. E. Stone, Bul. No. 105, 1905.
Blossom End Rot of Tomatoes, Elizabeth H. Smith, Tech. Bul. No. 3, 1907.
Seed Separation and Germination, G. E. Stone, Bul. No. 121, 1908.

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[1] These bulletins are no longer available for distribution by the Agricultural Experiment Station, but may be found in any public library within the State.

[2] Issued in co-operation with other departments.

Fungicides and Insecticides,[1] G. E. Stone, H. T. Fernald, Bul. No. 123, 1908.

Shade Trees,[2] E. A. Start, G. E. Stone, H. T. Fernald, Bul. No. 125, 1908.

Control of Onion Smut, G. E. Stone, Cir. No. 21, 1909.

Lime and Sulfur, G. E. Stone, Cir. No. 31, 1911.

Tomato Diseases, G. E. Stone, Bul. No. 138, 1911.

Microscopic Identification of Cattle Feeds, G. H. Chapman, Bul. No. 141, 1912.

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[1] Issued in co-operation with other departments.

[2] Issued in co-operation with the Massachusetts Forestry Association.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

This report is intended to give an outline of the work in progress by this department during the year ending Dec. 1, 1912.

1. Work of the Research Section.

(*a*) Work on the chemistry of insecticides undertaken in co-operation with the department of entomology has been largely completed, and a somewhat comprehensive paper on the subject was published in the twenty-fourth report. A paper on the chemistry of calcium arsenite was also presented by Mr. Holland to the International Congress of Applied Chemistry in September, 1912. Some additional work will be required for several years in testing the purity of the insecticides employed each year in spraying.

A reasonably satisfactory method has been developed for the quantitative determination of the insoluble fatty acids in butter fat. It is now being applied in the analysis of fat produced by cows at the beginning and end of lactation, and of that yielded by fat and thin cows at the beginning of lactation. The objection to the method is the length of time required for its completion. Another method is under consideration which, it is hoped, will yield equally good results in much less time.

The subject of the digestion depression produced by molasses has been further studied by noting its peristaltic action on the intestines. The observations confirmed those previously made, indicating it to be without noticeable effect.

(*b*) Mr. Morse has made distinct progress in his study of the effect of fertilizers upon asparagus. Phosphoric acid in the ash of the roots was not changed either by the absence or by varying the amounts of phosphate applied to the soil. Potassium oxide in the ash varied with the amounts of potash applied to the soil. Roots collected in the summer of 1911, at the close of cutting for market, showed no apparent exhaustion of nitrogen in them by withholding nitrate of soda until midsummer. Sugar was, however, somewhat depressed by the absence of a spring dressing of nitrate of soda. On the other hand, mature tops collected in October, 1911, gave results showing a small but persistent excess of nitrogen in samples from plots top-dressed with nitrate in the spring.

In case of the plant food requirements of the cranberry, the time has been devoted largely to observations to determine the probable amount of plant food which may be lost in the ditches as well as that which may rise through the peat and sand as the water rises and falls with the changes in rainfall, and the use of water for irrigation and flooding. The total amount added to the irrigation tiles during the summer of 1912 was equivalent to 190,000 gallons per acre. This should, theoretically, carry with it into the sand in which the roots grow some 53 pounds of nitrogen, 30 pounds of phosphoric acid and 85 pounds of potash per acre. Other studies are in progress.

A study of the action of sulfate of ammonia on several of the experiment station plots is in progress and considerable data are being accumulated which, it is hoped, will throw some light upon this perplexing problem.

(*c*) In addition to the above fundamental problems, Dr. Lindsey has continued his studies on the digestibility of cattle feeds, including cottonseed feed meal, cocoanut meal, flax and wheat screenings, flax shives and cocoa shells. An experiment concerning the value of alfalfa hay in milk production has also been completed, and observations are still in progress concerning milk substitutes for rearing dairy calves.

2. REPORT OF THE FERTILIZER SECTION.

Mr. Haskins reports as follows: —

Although the principal work of the fertilizer division has been confined to the inspection of commercial fertilizers, yet during the winter months considerable work was accomplished along other lines. The time available was partly devoted to completing the ash analysis of asparagus roots, this being a continuation of work begun during 1911 in conjunction with fertilizer experiments with asparagus. The ash analysis of tobacco stalks preserved under different conditions has been made for the purpose of showing the variation in composition and of emphasizing the importance of conserving all of the plant food which is furnished by this class of material. The analysis of 14 samples of soil taken from different localities and at different depths has been made to show the tendency of potash to accumulate in the subsoil to a depth of from 3 to 5 feet. This work was undertaken for the purpose of confirming results of analysis of subsoils on field A, which showed a remarkable accumulation of potash. Some time has been given to co-operative work with the American Association of Official Agricultural Chemists, particularly with reference to the study of new and improved methods for the determination of nitrogen, phosphoric acid and potash. The writer has served the association for the past two years as referee on phosphoric acid. Considerable preliminary work has been done in preparation for vegetation experiments on fertilizers to be conducted during 1913. Free examination of refuse by-products, fertilizers and soils has been made for farmers and farmers' organizations as in the past; a more detailed account of this work will be found on a subsequent page.

A larger number of commercial fertilizers has been registered, collected and analyzed during the season than for any previous year. The following summaries will give a fair idea of the work involved and will show the condition of the fertilizer trade for the year: —

(*a*) Fertilizers registered.
(*b*) Fertilizers collected.
(*c*) Fertilizers analyzed.
(*d*) Trade values of fertilizing ingredients.
(*e*) Raw products and chemicals.
    (1) Materials furnishing nitrogen.
    (2) Materials furnishing potash.
    (3) Materials furnishing phosphoric acid.

(*f*) Mixed complete fertilizers.
    (1) Grades of fertilizer.
    (2) Summary of analyses and guarantees.
    (3) Quality of plant food.
(*g*) Ground rock, mineral fertilizer or stonemeal.
(*h*) Lime compounds.
(*i*) Free analyses of by-products, fertilizers and soils.

(*a*) *Fertilizers registered.*

Ninety-seven manufacturers, importers and dealers, including the various branches of the trusts, have secured certificates for the sale of 509 different brands of fertilizer, agricultural chemicals, raw products and agricultural lime in the Massachusetts markets. This is 17 more than were registered during the previous year. They may be classed as follows: —

Complete fertilizers,	328
Fertilizers furnishing phosphoric acid and potash,	9
Ground bone, tankage and dry ground fish,	55
Chemicals and organic nitrogen compounds,	91
Agricultural limes,	26
	509

(*b*) *Fertilizers collected.*

An effort has been made to procure a representative sample of every brand of fertilizer and lime which has been registered in Massachusetts, and with few exceptions the effort has been successful. During the early part of April, arrangements were made, upon request, to sample carloads of cottonseed meal, wood ashes, fertilizers and chemicals, these earlier shipments being materials which were purchased for private use by some of the larger consumers. Although this practice has made it necessary to make a much larger number of analyses than formerly, yet it has some good features as it insures the inspection of a larger tonnage than would otherwise be possible, besides furnishing the large consumer an analysis of his particular shipment. Large shipments of many private formulas have been sampled upon request.

The inspectors have, during the year, sampled about 5,600 tons of fertilizer of all kinds, and in doing this have drawn from over 15,000 bags. They visited 138 towns, called upon 329 different agents, and drew 1,180 samples representing 527 distinct brands; this is 117 more samples, representing 45 more brands, than were taken during the previous year.

(*c*) *Fertilizers analyzed.*

Seven hundred and two analyses have been made during the year's inspection; they may be grouped as follows: —

Complete fertilizers,	431
Fertilizers furnishing phosphoric acid and potash, such as ashes,	16
Ground bone, tankage and fish,	68
Nitrogen compounds, both organic and mineral,	87
Potash compounds,	42
Phosphoric acid compounds,	33
Lime compounds,	25
	702

(*d*) *Trade Values of Fertilizing Ingredients.*

At a meeting of representatives of the experiment stations of New England, New York and New Jersey, held during the first week of March, 1912, the following table of trade values was adopted. The trade values represent the average cash cost per pound at retail of nitrogen, potash and phosphoric acid as furnished by chemicals and standard unmixed fertilizing material in the principal markets in New York and New England. The data which are used in obtaining these values are the average wholesale quotations of chemicals and raw materials as found in commercial publications from Sept. 1, 1911, to March 1, 1912, plus about 20 per cent.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals for 1911 and 1912.

	Cents per Pound.	
	1911.	1912.
Nitrogen: —		
In ammonia salts,	16.00	16.50
In nitrates,	16.00	16.50
Organic nitrogen in dry and fine ground fish, meat and blood,	23 00	22 00
Organic nitrogen in fine [1] bone, tankage and mixed fertilizers,	20 00	19.00
Organic nitrogen in coarse [1] bone and tankage,	15.00	15.00
Organic nitrogen in cottonseed meal, castor pomace, linseed meal, etc.,	21.00	20.00
Phosphoric acid: —		
Soluble in water,	4.50	4.50
Soluble in neutral ammonium citrate solution (reverted phosphoric acid),[2]	4 00	4.00
In fine-ground [1] bone and tankage,	4.00	4.00
In coarse [1] bone, tankage and ashes,	3.50	3.50
In cottonseed meal, castor pomace and linseed meal,	4 00	4.00
Insoluble (in neutral ammonium citrate solution) in mixed fertilizers,	2.00	2.00
Potash: —		
As sulfate free from chlorides,	5.00	5.25
As muriate (chloride),	4.25	4.25
As carbonate,	8.00	8.00
In cottonseed meal, castor pomace, linseed meal, etc.,	5.00	5.00

[1] Fine bone and tankage are separated from coarse bone and tankage by means of a sieve having circular openings one-fiftieth of an inch in diameter. Valuations of bone and tankage are based upon degree of fineness as well as upon composition.

[2] Dissolved by a neutral solution of ammonium citrate, specific gravity, 1.09, in accordance with method adopted by the Association of Official Agricultural Chemists.

(*e*) *Raw Products and Chemicals.*

Forty-five samples of ground bone, representing 32 analyses, have been collected and examined. The average retail cash price has been $32.63, and the average commercial valuation as calculated by the table of trade values has been $29.24. Ground bone has averaged 3.12 per cent. nitrogen, 75.32 per cent. of which has been found active by the alkaline permanganate method.

Twenty-eight samples of tankage have been inspected. The average retail cash price for tankage has been $33.19, and the average commercial valuation as calculated by the table of trade values has been $33.05 per ton. Tankage has averaged 6.58 per cent. total nitrogen, of which 75.38 per cent. has been found active by the alkaline permanganate method. Nitrogen in fine tankage has cost on the average 19.08 cents; nitrogen in coarse tankage has cost 15.06 cents per pound.

Four analyses of dissolved bone have been made. The average retail cash price has been $30.25, and the average commercial valuation as calculated by the table of trade values has been $23.27 per ton. Dissolved bone has averaged 2.60 per cent. nitrogen, 71.16 per cent. of which has been found active by the alkaline permanganate method.

Thirteen analyses of dry ground fish have been made, representing 32 samples. The average retail cash price per ton has been $42.16 and the average calculated commercial valuation $41.59 per ton. Nitrogen from dry ground fish has cost on the average 22.3 cents per pound.

(1) *Materials furnishing Nitrogen.* — Eight samples of dried blood have been examined, representing 6 analyses. Blood has averaged 10.46 per cent. total nitrogen, about 74 per cent. of which has been found active by the alkaline permanganate method. The average retail cash price for blood has been $50.74 per ton, and the average calculated commercial valuation, $48.26 per ton. The average pound cost of nitrogen from blood has been 23.13 cents.

Two samples of castor pomace have been analyzed, both of which have been found up to the guarantee. The average retail cash price has been $25.50, and the average commercial valuation calculated by the table of trade values has been $19.24 per ton. The average cost of nitrogen in this form has been 26.51 cents per pound. Castor pomace has shown on the average 4.81 per cent. nitrogen, about 54 per cent. of which has been found active by the alkaline permanganate method.

Fifty-six samples of cottonseed meal have been examined. Each sample represents a carload, and all of the material inspected was bought as a nitrogen source, largely for tobacco. The average retail cash price has been $31.45, and the average calculated commercial valuation, $25.95 per ton. The average pound cost of nitrogen in this form has been 24.24 cents. Cottonseed meal has averaged 6.49 per cent. nitrogen, about 56 per cent. of which has been found active by the alkaline permanganate method.

Thirty-nine samples of nitrate of soda have been examined, representing 16 analyses: all but one sample was found fully up to the guarantee. Nitrate of soda has cost on the average

$50.70, and the average commercial valuation calculated by the table of trade values has been $51.03 per ton. The pound price of nitrogen from this source has been 16.39 cents.

Six analyses of sulfate of ammonia have been made, representing 7 samples; all have been found of good quality. The average retail cash price per ton has been $71.13, and the calculated commercial valuation, $72.28 per ton. The average cost of a pound of nitrogen in this material has been 16.23 cents.

(2) *Materials furnishing Potash.* — Eighteen analyses of high-grade sulfate of potash have been made, representing 31 samples. The average retail cash price of this potash salt has been $50.78, and the average commercial valuation calculated from the table of trade values has been $51.47 per ton. The pound of actual potash in this form has cost on the average 5.18 cents.

Five analyses of potash-magnesia sulfate have been made, representing 9 samples. The average retail cash price has been $29.50, and the average commercial valuation calculated from the table of trade values has been $28.80 per ton. The pound of actual potash in this form has cost 5.38 cents.

An article offered as double sulfate of magnesia and potash was not *bona fide,* but evidently high-grade sulfate of potash and sulfate of magnesia reduced with sand. It contained 21.6 per cent. material insoluble in hot water, the greater part of which was unquestionably sand. The case is probably similar to several which were detected last year, and which proved to be cases where the mines in Germany had reduced high-grade sulfate of potash with sand in order to fill orders for potash-magnesia sulfate, of which there was a temporary shortage. Dr. Huston, of the German Kali Works, states that the practice is not tolerated by his company, and heavy shipments have been returned at the expense of the mines furnishing the material, and in all cases where this practice has been detected heavy fines have also been imposed. The amount of material involved in this particular case was not large, only 1½ tons being bought by one party for his own use.

Fifteen analyses of muriate of potash have been made, representing 31 samples. The potash guarantee was maintained in all but one case, and in this exception the commercial shortage was less than 50 cents per ton. The average retail cash price has been $42.58, and the calculated commercial valuation, $43.83 per ton. The pound of actual potash as muriate has cost on the average 4.13 cents.

(3) *Materials furnishing Phosphoric Acid.* — Only two samples of dissolved bone black have been analyzed, one of which showed a commercial shortage of over 50 cents per ton.

Fourteen analyses of acid phosphate have been made, representing 25 samples. The average retail cash price has been $15.35, and the average commercial valuation calculated from the table of trade values has been $13.67 per ton. The pound of available phosphoric acid from acid phosphate has cost 4.77 cents.

Seventeen analyses of basic slag phosphate have been made, representing 23 samples. Four analyses showed samples deficient in available phosphoric acid. The average retail cash price paid for basic slag was $15.19, and the average calculated commercial valuation, $12.64 per ton. The pound of available phosphoric acid from basic slag, as determined by the Wagner method, has cost on the average 4.81 cents. Two brands showed a commercial shortage of over 50 cents per ton.

(*f*) *Mixed Complete Fertilizers.*

The larger number of high-grade fertilizers that are being sold from year to year in Massachusetts indicates that the average farmer realizes the importance of purchasing a high-grade mixture. As has been pointed out in past years, there are many advantages to be gained by choosing a formula from among the high-grade goods. Summary tables have been prepared which furnish valuable data bearing upon this point.

(1) *Grades of Fertilizer.* — In separating the formulas into different grades, those brands containing plant food having a commercial value of $24 or over per ton have been classed as high grade, those having a value between $18 and $24 per ton medium grade, and those having a value of $18 or less per ton low grade.

Table showing Average Cash Price and Commercial Plant Food Value per Ton, also Money Difference between Cash Price and Plant Food Value.

	HIGH GRADE.		MEDIUM GRADE.		LOW GRADE.	
	1911.	1912.	1911.	1912.	1911.	1912.
Average retail cash price a ton,	$40.87	$38.23	$35.08	$33.26	$29.64	$29.76
Average retail cost of plant food in a ton.	28.89	27.84	21.04	20.74	15.37	14.58
Average money difference, .	11.98	11.16	14.04	12.52	14.27	15.16

The above table shows: —

1. That the average ton price of the three grades of fertilizer has been $1.42 less, and the average cost of plant food in a ton 66 cents less, than for the previous season.

2. That the low-grade goods were the only class which sold on the average at a slightly higher ton cost than during the previous year.

3. That the percentage excess of the selling price over the commercial value of plant food in the low-grade fertilizers is over two and one-half times more than in the high-grade goods, and about one and three-fourths times more than in the medium-grade fertilizers.

4. That with a 28.5 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes about 91 per cent. increase in commercial plant food value.

5. That the money difference between the average selling price and the average valuation in the high-grade fertilizers is $4 less than in the low-grade goods. It probably costs no more to manufacture a ton of low-grade goods than it does a ton of the high-grade; besides, in the low-grade fertilizer opportunities are offered for the use of low-grade ammoniates and low-grade potash compounds. These facts all emphasize the many advantages to be gained by buying only high-grade mixtures.

Table showing the Average Composition of the Three Grades of Fertilizer.

GRADE.	Number of Brands.	Per Cent. of Whole Number.	NITROGEN.			PHOSPHORIC ACID.			Potassium Oxide.	Pounds of Available Plant Food in 100 Pounds of Fertilizer.
			Total.	Percentage Availability of Total Nitrogen.	Percentage Availability of Organic Nitrogen.	Soluble.	Reverted.	Available.		
High, . . .	165	48.25	3.94	85.28	68.65	3.90	3.52	7.42	7.75	19.11
Medium, . .	105	30.88	2.59	83.40	64.46	4.46	3.25	7.71	5.08	15.38
Low, . . .	72	21.18	1.66	75.90	60.00	4.36	2.74	7.10	2.83	11.59

The above table shows: —

1. That a ton of the average high-grade fertilizer furnishes 45.6 pounds more nitrogen and 98.4 pounds more actual potash than does a ton of the low-grade goods.

2. That a ton of the average high-grade fertilizer furnishes 27 pounds more nitrogen and 53.4 pounds more potash than does a ton of the medium-grade goods.

3. That with a 28.5 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes about 65 per cent. increase in available plant food.

4. That the average high-grade fertilizer with about 15 per cent. advance in price over the medium-grade goods, furnishes over 24 per cent. more plant food and 34 per cent. increase in commercial value.

5. That the percentage activity of the total nitrogen is 9.38 per cent., and the percentage activity of the organic nitrogen is 8.65 per cent. more in the high-grade fertilizer than in the low-grade brands. This would indicate the superior quality of plant food in the high-grade brands, which is still another advantage in purchasing the latter class of fertilizer.

Table showing the Comparative Pound Cost of Nitrogen, Potash and Phosphoric Acid in its Various Forms in the Three Grades of Fertilizer.

FORM OF ELEMENT.	Low-grade Fertilizer (Cents).	Medium-grade Fertilizer (Cents).	High-grade Fertilizer (Cents).
Nitrogen (as nitrates and ammoniates),	33.7	26.5	22.6
Nitrogen (organic),	38.8	30.5	26.1
Potash (as muriate),	8.7	6.8	5.8
Soluble phosphoric acid,	9.2	7.2	6.2
Reverted phosphoric acid,	8.2	6.5	5.5
Insoluble phosphoric acid,	4.1	3.2	2.7

This table shows: —

1. That the purchase of high-grade fertilizers in place of low-grade has saved nearly 12 cents on every pound of nitrogen and nearly 3 cents on every pound of potash and phosphoric acid.

2. That the purchase of high-grade fertilizers in place of medium grade has saved 4¾ cents on every pound of nitrogen and nearly 2 cents on every pound of potash and phosphoric acid.

3. That the cost of the several elements of plant food in the average high-grade fertilizer amounts to $37.65 a ton. If the farmer purchases this same amount of plant food on the basis of the cost of the fertilizer elements in the low-grade fertilizer, he would pay $56.17. In other words, he would pay $18.52 more for the same plant food if purchased in the form of low-grade fertilizer; and he would pay $12.06 more for it if purchased in the form of medium-grade fertilizer.

4. That about 52 per cent. of the brands of fertilizer sold in the State are classed as low and medium grade. This is by far too large a proportion, as it means that those purchasing this class of goods are paying an excessive price for the actual plant food obtained, which in the aggregate must amount to many thousands of dollars.

5. That it would be much more economical to buy only high-grade fertilizers and use less per acre. The brand should be selected which comes nearest fulfilling the plant-food requirements in each individual case.

(2) *Summary of Results of Analyses of the Complete Fertilizers as compared with the Manufacturer's Guarantee.*

Manufacturer.	Number of Brands analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	3	2	3	1	–	–
Alphano Humus Company,	1	1	1	–	–	–
American Agricultural Chemical Company,	76	33	66	34	8	1
Armour Fertilizer Works,	10	6	10	4	–	–
Beach Soap Company,	6	4	6	2	–	–
Berkshire Fertilizer Company,	15	12	15	3	–	–
Bowker Fertilizer Company,	26	19	23	6	1	–
Jos. Breck & Sons,	3	1	3	2	–	–
Buffalo Fertilizer Company,	8	6	7	2	–	–
The E. D. Chittenden Company,	6	4	5	1	1	–
Clay & Son,	1	1	1	–	–	–
Coe-Mortimer Company,	17	10	16	6	1	–
Eastern Chemical Company,	1	–	1	1	–	–
Essex Fertilizer Company,	9	2	6	5	2	–
C. W. Hastings,	1	1	1	–	–	–
Hubbard Fertilizer Company,	5	1	5	1	3	–
Listers' Agricultural Chemical Works,	9	6	9	3	–	–
J. E. McGovern,	1	1	1	–	–	–
Mapes' Formula and Peruvian Guano Company,	18	14	18	4	–	–
National Fertilizer Company,	15	6	11	9	1	–
Natural Guano Company,	1	1	1	–	–	–
New England Fertilizer Company,	7	6	7	1	–	–
Olds & Whipple,	7	6	7	1	–	–
Parmenter & Polsey Fertilizer Company,	8	6	8	1	1	–
R. T. Prentiss,	3	2	2	1	–	–
Pulverized Manure Company,	2	1	1	–	–	1
Rogers Manufacturing Company,	10	7	10	3	–	–
Rogers & Hubbard Company,	9	8	9	1	–	–
Ross Bros. Company,	4	2	3	2	–	–
Sanderson Fertilizer and Chemical Company,	8	5	8	3	–	–
M. L. Shoemaker & Co., Ltd.,	2	2	2	–	–	–
Swift's Lowell Fertilizer Company,	16	12	16	4	–	–
20th Century Specialty Company,	3	2	3	1	–	–
Wm. Thomson & Sons,	2	1	2	1	–	–
Whitman & Pratt Rendering Company,	5	5	5	–	–	–
Wilcox Fertilizer Company,	9	9	9	–	–	–
A. H. Wood & Co.,	3	2	3	1	–	–

This table shows: —

1. That out of a total of 330 brands of complete fertilizers collected and analyzed, 124 (38 per cent. of the total number) fell below the manufacturer's guarantee in one or more elements.

2. That 104 brands were deficient in one element.

3. That 18 brands were deficient in two elements.

4. That 2 brands were deficient in all three elements.

5. That 26 brands (about 8 per cent. of the whole number analyzed) showed a commercial shortage; that is, the value of the plant food found did not equal the value of the plant food

guaranteed, although overruns were used to offset shortages. The deficiencies found were divided as follows: —

73 brands were found deficient in nitrogen.
31 brands were found deficient in available phosphoric acid.
42 brands were found deficient in potash.

6. That, compared with the previous year, a much better showing has been made. Fewer deficiencies have occurred, also a less number of commercial shortages. The number of nitrogen, available phosphoric acid and potash shortages were, respectively, 23 less, 59 less and 24 less than for the season of 1911. The brands showing a commercial shortage were 2 less than for the previous year.

Table showing Commercial Shortages (25 Cents and Over) in Mixed Commercial Fertilizers for 1911 and 1912.

COMMERCIAL SHORTAGES.	NUMBER OF BRANDS.	
	1911.	1912.
Between $1 and $2 per ton, ...	9	8
Under $1, not less than 25 cents per ton, ...	17	15

A number of instances have occurred, as is frequently the case, where serious shortages of some one element have been found and yet the brands have not suffered a commercial shortage, the deficiencies being made up by overruns of some other element. Although this is not a desirable feature, perhaps it cannot always be avoided in the rush season.

(3) *Quality of Plant Food.* — A very full discussion of the quality of the plant food entering into the composition of mixed fertilizers will be found in our Fertilizer Bulletin No. 143. In general it may be said that the quality of the organic nitrogen used in fertilizers found in the Massachusetts markets showed an improvement over last year. The phosphoric acid guarantees, as a whole, were well maintained. There are indications that considerable nonacidulated phosphoric-acid-containing material enters into the composition of mixed fertilizers, being probably derived from tankage and partly acidulated bone. The potash guarantees were better maintained than during the

past year, and in most instances the form of potash was as guaranteed. The misleading practice of stating the sulfate of potash equivalent when the potash is actually present in form of muriate is still prevalent to some extent. Every formula has, therefore, been tested to show the form of potash actually present.

(*g*) *Ground Rock, Mineral Fertilizer or Stonemeal.*

The indications are that not much of this class of materials has been sold in the Massachusetts markets. The inspectors were not able to find it in the hands of agents, and it was probably sold by the manufacturer through soliciting agents direct to the farmer.

A sample of New Mineral Fertilizer, manufactured by the New Mineral Fertilizer Company of Boston, was taken by one of our inspectors from stock carried by the manufacturer. The analysis of this showed the presence of .09 per cent. nitrogen, .38 per cent. total phosphoric acid and .10 per cent water-soluble potash. The calculated commercial value of the material was 57 cents per ton. Extravagant claims are made by the company for the fertilizing value of the silica, chlorine, sulfur, soda, lime, magnesia, iron and alumina which the material, like all rocks and soils, contains. The ordinary soil usually contains an abundance of these elements with the possible exception of lime. Assuming the ton price to be the same as last year, $17, a pound of nitrogen would have cost $5.67, a pound of insoluble phosphoric acid 60 cents, and a pound of water-soluble potash $1.27.

Dr. Charles D. Woods, director of the Maine Agricultural Experiment Station, has conducted field experiments with this material.[1] The results of the experiment were stated as follows by Director Woods: —

> "It will be noted that both with the corn and with the potatoes, there was a somewhat smaller yield on the plots to which New Mineral Fertilizer was applied than upon the plots which received no fertilizer. The comparative yields seem clearly to point out that there was no benefit from the use of the New Mineral Fertilizer."

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[1] See description of the experiment in the American Fertilizer, Philadelphia, Pa., Vol. XXXVII., No. 9, pp. 28-29.

The Massachusetts station intends to conduct some experiments with this fertilizer the coming season.

Two samples of Stonemeal, manufactured by the Stonemeal Fertilizer Company of Paterson, N. J., who have an office in Springfield, Mass., were collected and analyzed. Although this material contains a little more potash and phosphoric acid than did the New Mineral Fertilizer, yet it must be placed in the same class.

(*h*) *Lime Compounds.*

Our new fertilizer law was drafted to include the inspection of lime used for agricultural purposes. The year 1912 marks the first official inspection of lime which has ever been made in the State.[1]

Forty-four samples representing 21 brands were taken from 36 different agents in 24 different towns; 25 analyses have been made.

Lime for agricultural purposes includes slaked or hydrated lime, caustic or burnt lime, carbonate of lime, such as ground limestone, marl and wood ashes; also gypsum or land plaster (sulfate of lime). Detailed results of the analyses will be found in our Fertilizer Bulletin, including the actual cost of 100 pounds of calcium and magnesium oxides derived from different sources.

(*i*) *Free Analysis of By-products, Fertilizers and Soils.*

Two hundred and sixty-three different substances have been received and analyzed from farmers, farmer organizations and the various departments of the experiment station. The materials may be classed as follows: fertilizers and by-products used as fertilizers, 200; soils, 40; lime compounds, 13; ash analysis of plants, 8; miscellaneous products, 2.

Many of these materials have been sampled by our regular inspectors; some were taken by the party requesting the analysis by means of a sampling tube forwarded from the station for that purpose. In all cases the samples were drawn according to directions furnished from this office. It may be assumed, therefore, that the samples were representative of the products in question. In reporting results of analysis, full information is given as to commercial value of the product and the best manner of using it. In many cases where a by-product does not have the plant food constituents present in the right proportion, suggestions are made as to the best manner of balancing the material by the addition of chemicals. In reporting analyses of lime products it has been the custom to furnish not only the chemical analysis but also the probable proportion of the various forms of lime and magnesia present; *i.e.,* whether caustic, hydrated (slaked) or carbonate of lime and magnesia were present, and amounts of each.

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[1] For a discussion of the rational use of lime, ask for Bulletin No. 137.

In reporting soil analysis, information has been furnished as to treatment with lime, manures and fertilizers.

With the exception of some of the lime products, chemicals and complete fertilizer formulas which have been collected by our inspectors, and which appear in a table by themselves in the Fertilizer Bulletin, the analyses above mentioned will not be published.

3. Report of the Feed and Dairy Section.

Mr. P. H. Smith submits the following: —

The Feed Law (Acts and Resolves for 1903, Chapter 122).

During the year, 902 samples of commercial feeding stuffs have been collected by James T. Howard, official inspector. These samples have been examined, and the analytical results together with additional information are given in Bulletin No. 142.

The year has been uneventful in that the law has been well complied with, and few new feeding stuffs have been found. Prices have ruled high, and our inspector reports that the stock on hand has been, during parts of the year, very low. This was due to the difficulty of getting shipments promptly and to the fact that, owing to the uncertainty of the market, dealers did not care to stock heavily.

The most important event of the year was the enactment of a new feeding stuffs law which took effect Sept. 1, 1912. This law is printed in full in Bulletin No. 142 of this station and also as Circular No. 34.

The new law differs from the law which it replaces in the following essentials: —

1. *Guarantee.* — In addition to a guarantee of the minimum percentage of protein and fat, as formerly required, a guarantee of the maximum fiber content must also be given. In case of mixed or compounded feeds, a statement of the ingredients contained therein must be included in the guarantee.

2. *Registration.* — Registration of all feeding stuffs is now necessary, although no fee is required. Upon application, the proper forms for registration will be forwarded.

3. *Appropriation.* — In place of the $3,000 formerly allowed for carrying out the provisions of the act, $6,000 is now appropriated.

4. *Phraseology.* — The law has been put in such form as to be more explicit in the statement of its requirements. Before being submitted for enactment, the text was carefully reviewed not only by officials of this station, but by those of other experiment stations, and also by a committee of feed dealers from the Boston Chamber of Commerce. It was finally submitted to a competent attorney for corrections and approval.

5. *Wheat feeds* are now included; in the former law these were omitted.

The law practically conforms to the uniform law advocated by the Association of Feed Control Officials, which has received the indorsement of the American Feed Manufacturers' Association.

It is felt that the new law will more effectually safeguard the interests of the Massachusetts farmer than the former act, and that the compliance with its requirements will not be any more difficult for the honest manufacturer or jobber. The earnest co-operation of all interested in the manufacture, sale or consumption of commercial feeding stuffs is most earnestly desired.

The acknowledgment is made of the co-operation of members of the Boston Chamber of Commerce, of the secretary of the State Board of Agriculture, of a representative of the State Grange, and of others in securing the passage of the law.

The Dairy Law (*Acts and Resolves for 1912, Chapter 218*).

This act as originally passed in 1901 required that all persons using the Babcock test as a basis of payment for milk or cream, either in buying or selling, must secure a certificate of proficiency from the experiment station. It also required that Babcock machines be inspected by an experiment station official annually, and that all glassware be tested for accuracy by the station. The act was amended in 1909 (chapter 425, Acts and Resolves for 1909), giving to the director of the experiment station the authority to revoke the certificate of an operator found to be using dirty or untested glassware or doing the work in an improper manner.

A redraft of the entire law made to include milk inspectors was presented to and passed by the Legislature of 1912, the full text of which follows: —

AN ACT TO REGULATE THE USE OF UTENSILS FOR TESTING THE COMPOSITION OR VALUE OF MILK AND CREAM.[1]

Be it enacted, etc., as follows:

SECTION 1. No bottle, pipette, or other measuring glass or utensil shall be used in this commonwealth by any inspector of milk or cream, or by any person in any milk inspection laboratory, in determining, by the Babcock or other centrifugal machine, the composition of milk or cream for the purposes of inspection; or by any person in any milk depot, creamery, cheese factory, condensed milk factory or other place in determining, by the Babcock or other centrifugal machine, the composition or value of milk or cream as a basis for payment in buying or selling, until it has been tested for accuracy and verified by the director of the Massachusetts agricultural experiment station, or by his duly designated deputy or deputies. Every such bottle, pipette, or other measuring glass or utensil shall be submitted to the said director by the owner or user thereof, to be tested for accuracy before the same is used in this commonwealth for the purposes aforesaid. The owner or user shall pay to the said director for the use of the said station as a fee for making the test, a sum not exceeding five cents for each bottle, pipette, or other measuring glass or utensil tested. Any bottle, pipette, or other measuring glass or utensil that has been tested and verified as aforesaid shall be marked by the director or by his said deputy or deputies to indicate the fact, or if tested and found to be inaccurate may be marked by him or them to indicate that it is inaccurate. No bottle, pipette, or other measuring glass or utensil that has been marked by the said director, or by his duly designated deputy or deputies, to indicate that it is inaccurate shall be used in this commonwealth by any person in determining the composition or value of milk or cream.

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[1] Chapter 218, Acts and Resolves of 1912.

SECTION 2. Every Babcock or other centrifugal machine used in this commonwealth by any inspector of milk or cream, or by any person in any milk inspection laboratory for determining the composition of milk or cream for purposes of inspection, or by any person in any milk depot, creamery, cheese factory, condensed milk factory or other place for determining the composition or value of milk or cream as a basis for payment in buying or selling, shall be subject to inspection at least once in each year by the director of the Massachusetts agricultural experiment station or by an inspector or deputy of the said director. The owner or user of any such centrifugal machine shall pay to the said director for the use of said station as a fee for making such annual inspection the actual cost of such inspection for each machine inspected.

Any Babcock or other centrifugal machine used as aforesaid that is not, in the opinion of the director, or of an inspector or deputy of the said director, in condition to give accurate results, may be condemned by the director or by his inspector or deputy. No Babcock or other centrifugal machine that has been condemned by said director or by an inspector or deputy of the director as not in condition to give accurate results shall be used in this commonwealth by any person for determining the composition or value of milk or cream as aforesaid, unless the machine be changed to the satisfaction of the said director or of his inspector or deputy, and approved by him.

SECTION 3. No inspector of milk or cream, and no person in any milk inspection laboratory, shall manipulate the Babcock or other centrifugal machine for the purpose of determining the composition of milk or cream for purposes of inspection, and no person in any milk depot, creamery, cheese factory, condensed milk factory, or other place in this commonwealth shall manipulate the Babcock or other centrifugal machine for the purpose of determining the composition or value of milk or cream as a basis for payment in buying or selling, without first obtaining a certificate from the director of the Massachusetts agricultural experiment station, or his duly designated deputy, that he is competent to perform such work. The fee for such certificate shall be two dollars, and shall be paid by the applicant therefor to the said director for the use of the said station. In case any holder of a certificate is notified by the director, or by his duly designated deputy, to correct his use of a Babcock or other centrifugal machine, the actual cost of making an inspection to ascertain if the said person has corrected his use of the said machine shall be paid by the said person or by his employer to the director for the use of the said station. No holder of a certificate whose authority to manipulate a Babcock or other centrifugal machine has been revoked by the director of the Massachusetts agricultural experiment station, or by his duly designated deputy, shall thereafter manipulate in this commonwealth any centrifugal machine for the purposes aforesaid.

SECTION 4. The director of the Massachusetts agricultural experiment station and his duly designated deputy are hereby authorized to issue certificates of competency to such persons desiring to manipulate the Babcock or other centrifugal machine as, in the opinion of the director or his deputy, are competent to manipulate said machines. The said director or his deputy may make and enforce rules governing applications for such certificates and the granting thereof and may, in his discretion, revoke the authority of any holder of a certificate who, in the opinion of the director or of his deputy, or of an inspector of the said director, is not correctly manipulating any centrifugal machine as aforesaid, or is using dirty or otherwise unsatisfactory glassware or utensils.

SECTION 5. It shall be the duty of the director of the Massachusetts agricultural experiment station, and he is hereby authorized, to test or cause to be tested all bottles, pipettes and other measuring glasses or utensils submitted to him as provided in section one, to inspect or cause to be inspected at least once each year every Babcock or other centrifugal machine used in this commonwealth by an inspector of milk or cream, or by any person in any milk inspection laboratory, for purposes of inspection, or by any person in any milk depot, creamery, cheese factory, condensed milk factory, or other place for determining the composition or value of milk or cream as a basis for payment in buying or selling, and to collect or cause to be collected for the use of said station the fees or actual cost of tests and inspections provided for in this act. The said director, his inspectors and deputies are further authorized to enter upon any premises in this commonwealth where any centrifugal machine is used as aforesaid to inspect the same and to ascertain if the provisions of this act are complied with.

SECTION 6. Any person hindering or obstructing the director of the Massachusetts agricultural experiment station, or any inspector or deputy of the said director, in the discharge of the authority or duty imposed upon him or them by any provision of this act, and any person violating any of the provisions of sections one, two and three of this act shall be punished by a fine of not less than fifteen and not more than fifty dollars for each offense.

SECTION 7. It shall be the duty of the director of the Massachusetts agricultural experiment station to see that the provisions of this act are complied with, and he may in his discretion prosecute or cause to be prosecuted any person violating any provision of this act. But this act shall not be construed to affect any persons using any centrifugal or other machine or test in determining the composition or value of milk or cream when such determination is made for the information of such persons only, and not for purposes of inspection, or as a basis for payment in buying or selling.

Section 8. A sum not exceeding five hundred dollars yearly shall be allowed and paid out of the treasury of the commonwealth to meet the cost of prosecutions under this act, to be paid upon the presentation to the treasurer of the commonwealth by the director of the Massachusetts agricultural experiment station of proper vouchers therefor.

Section 9. The word "person" as used in this act shall include a corporation, association or partnership or two or more persons having a joint or common interest.

Section 10. Sections sixty-five to sixty-nine, inclusive, of chapter fifty-six of the Revised Laws, and chapter four hundred and twenty-five of the acts of the year nineteen hundred and nine are hereby repealed.

Section 11. This act shall take effect on the first day of July in the year nineteen hundred and twelve. [*Approved March 9, 1912.*

Summary of Inspection.

1. *Examination for Certificates.* — Applicants are examined in both theory and practice of the Babcock test. Of those who have applied during the year, 28 candidates were given certificates, while 5 have been refused.

2. *Examination of Glassware.* — Six thousand and fifty-six pieces of Babcock glassware have been tested, of which only 27 pieces were condemned as inaccurate. The amount of untested glassware at present is very small as compared with that found formerly, and confirms the usefulness of the law.

Following is a summary for the twelve years the law has been in force: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
Totals,	40,208	1,924	4.79[1]

[1] Average.

3. *Inspection of Machinery and Apparatus.* — Mr. James T. Howard as deputy inspector has visited and inspected the Bab-

cock machines and apparatus in 80 creameries, milk depots and milk inspectors' laboratories. Nine operators were found using untested glassware, and 15 operators were ordered to repair or replace machines in use. As the law in its application to milk inspectors is new, no prosecutions are being considered at this time; it is believed that all will eventually conform to the law. Following is a list of milk depots, creameries and milk inspectors visited. Only those milk inspectors using the Babcock test are listed.

1. *Creameries.*

Location.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, manager.
2. Amherst,	Fort River,[1]	E. A. King Estate, Proprietors.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrell, manager.
8. Easthampton,	Easthampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	Walter Solomon, proprietor.
11. Monterey,	Berkshire Hills,	F. A. Campbell, manager.
12. Northfield,	Northfield Co-operative,	John E. Nye, manager.
13. Shelburne,	Shelburne Co-operative,	I. R. Barnard, manager.
14. Wyben Springs,	Wyben Springs Co-operative,	C. H. Kelso, manager.

[1] Testing done at Massachusetts Agricultural Experiment Station.

2. *Milk Depots.*

Location.	Name.	Manager.
1. Boston,	Boston Condensed Milk Company,	R. Burns.
2. Boston,	Boston Jersey Creamery,	E. F. Luce.
3. Boston,	Elm Farm Milk Company,	J. H. Knapp.
4. Boston,	Franklin Creamery,	O. Bradford.
5. Boston,	H. P. Hood & Sons,	C. H. Hood.
6. Boston,	Oak Grove Farm,	John Alden.
7. Boston,	Plymouth Creamery Company,	R. Gardner.
8. Boston,	Turner Center Dairying Association,	I. L. Smith.
9. Boston,	Walker-Gordon Laboratory,	G. Franklin.

LOCATION.	Name.	Manager.
10. Boston,	D. Whiting & Sons,	George Whiting.
11. Cambridge,	C. Brigham Company,	J. K. Whiting.
12. Cheshire,	Ormsby Farms,	E. B. Penniman.
13. Lawrence,	Crescent Creamery,	E. Morgan.
14. Newburyport,	Newhall's Milk Depot,	John A. Newhall.
15. Pittsfield,	H. H. Prentice & Co.,	H. H. Prentice.
16. Sheffield,	Willow Brook Dairy,	Frank Percy.
17. Southborough,	Deerfoot Farm,	C. H. Newton.
18. Springfield,	Tait Brothers,	H. Tait.

3. *Milk Inspectors.*

LOCATION.	Inspector.	LOCATION.	Inspector.
1. Adams,	A. G. Potter.	26. Newton,	Arthur Hudson.
2. Andover,	F. H. Stacey.	27. New Bedford,	H. B. Hamilton.
3. Amesbury,	E. L. Worthen.	28. North Adams,	H. Tower.
4. Arlington,	L. L. Pierce.	29. Northampton,	G. R. Turner.
5. Barnstable,	Geo. T. Mecarta.	30. Peabody,	H. S. Pomeroy.
6. Boston,	J. O. Jordan.	31. Pittsfield,	E. L. Hannum.
7. Brockton,	G. G. Bolling.	32. Plainville,	John Eiden.
8. Cambridge,	Wm. A. Noonan.	33. Revere,	J. E. Lamb.
9. Chelsea,	W. S. Walkley.	34. South Hadley,	Geo. F. Boudreau.
10. Chicopee,	C. L. O'Brien.	35. Somerville,	H. E. Bowman.
11. Clinton,	G. L. Chase.	36. Springfield,	S. C. Downs.
12. Everett,	E. Clarence Colby.	37. Springfield,	Emerson Laboratory.[1]
13. Fall River,	Henry Boisseau.	38. Taunton,	L. I. Tucker.
14. Fitchburg,	John F. Bresnahan.	39. Wakefield,	J. S. Bonney.
15. Gardner,	C. W. Shippee.	40. Waltham,	Arthur L. Stone.
16. Greenfield,	Geo. P. Moore.	41. Ware,	Fred E. Marsh.
17. Haverhill,	H. L. Conner.	42. Watertown,	L. C. Simmons.
18. Holyoke,	D. P. Hartnett.	43. Wellesley,	F. Schneider, Jr.
19. Lawrence,	J. H. Tobin.	44. Westfield,	W. M. Porter.
20. Lowell,	Melvin Marster.	45. West Springfield,	Norman T. Smith.
21. Ludlow,	A. L. Bennett,	46. Winchendon,	G. W. Stanbridge.
21. Lynn,	H. P. Bennett.	47. Winchester,	Morris Dinneen.
23. Millbury,	F. A. Watkins,	48. Woburn,	E. P. Kelley.
24. Malden,	J. I. Sanford.	49. Worcester,	Gustav L. Berg.
25. Medford,	Winslow Joyce.		

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[1] Does work for the State Dairy Bureau.

Water Analysis.

There is no one feature of the home of greater importance than a pure and unfailing water supply. In order that families living where a public supply is not available may have the opportunity of determining the purity of the water from the well or spring they are obliged to use, the experiment station will make a chemical examination of the water at a nominal charge ($3 a sample). Water for examination must be shipped in containers, which will be sent to the applicant on request, and the blank forms sent with the container must be filled out and returned with the sample. A bacteriological examination is not made, and the chemical analysis is limited to those determinations which will indicate sewage contamination or the presence of lead or objectionable metals.

One hundred and ten samples were examined during the past year; of these there were 77 samples from wells, 28 from springs, 4 from ponds and 1 sample of ice. A large number of well waters examined were condemned. Some showed only slight contamination while others were pronounced dangerous for use.

Wells located close to dwellings and stables are particularly liable to contamination; hence great care should be exercised in the location of new wells. Where a well is known to be free from contamination it should be bricked or cemented up well above the surface of the ground in order to prevent the entrance of surface water during wet weather, and the top of the well should be made vermin proof.

Milk, Cream and Feeds for Free Examination.

In addition to the other work of this department, free analyses have been made of 372 samples of milk and 146 samples of feedstuffs. A large number of butter-fat tests on cream by the Babcock method have also been made.

As a general rule, it is preferred to have application made before a sample is submitted for analysis. Directions for proper sampling and for shipping can then be forwarded. An analysis of an improperly drawn sample may lead to erroneous conclusions. In the case of feeding stuffs an analysis is often unnecessary, as the experiment station has a large amount of analytical data on file which may apply to the sample submitted. This department will not act in the capacity of a commercial chemist, and will use its own discretion in accepting work of this character.

Miscellaneous Work.

In addition to the work already described, this section has conducted investigations, co-operated with other departments, or made analyses as follows: —

1. It has arranged and furnished exhibits and speakers in co-operation with the extension department for fairs, farmers' meetings and expositions.

2. It has co-operated with the Bowker Fertilizer Company in making starch determinations on potatoes in connection with the awarding of prizes.

3. It has co-operated with the agricultural department of the college in making analyses of milk in connection with the awarding of prizes at a dairy show held during "farmers' week."

4. In connection with the experimental work of this and other departments of the experiment station, this section has made analyses of 160 samples of milk, 129 samples of feed and 478 samples of agricultural plants.

Testing Pure-bred Cows.

The work of testing pure-bred cows for entry in the advanced register of the several pure-bred cattle associations continues to increase. During the year, thirteen different men have been used for the Holstein-Friesian work, and for a greater part of the time three men have been employed in the yearly tests for the Guernsey, Jersey and Ayrshire associations. From Dec. 1, 1910, to Dec. 1, 1911, 69 Guernsey, 94 Jersey and 4 Ayrshire tests have been completed. There are now on test 82 Guernseys, 106 Jerseys and 16 Ayrshires, located at 22 different farms. For the Holstein-Friesian Association there have been completed 124 seven-day tests, 7 thirty-day tests, 2 fourteen-day tests and 1 fifty-seven-day test.

The Jersey, Guernsey and Ayrshire clubs are formulating uniform rules for testing, and will probably, in the near future, adopt a one-day monthly test instead of the two-day test now in use.

4. Numerical Summary of Substances examined in the Chemical Laboratory.

The following substances have been received and examined: 110 samples of water, 372 of milk, 2,618 of cream, 146 feedstuffs, 200 fertilizers and fertilizer refuse materials, 40 soils, 13 lime products, 8 ash analyses of plants and 2 miscellaneous. There have also been examined in connection with experiments in progress by the several departments of the station, 160 samples of milk and cream, 129 cattle feeds and 478 agricultural plants. In connection with the control work there have been collected 1,180 samples of fertilizer and 902 samples of feedstuffs. The total for the year was 6,359.

The above does not include the work of the research section. In addition, 28 candidates have passed the examination and secured certificates to operate the Babcock test, and 6,056 pieces of Babcock glassware have been tested for accuracy, of which only 27 pieces, or .45 of 1 per cent., were condemned as inaccurate.

5. Correspondence.

The number of letters sent during the year approximates 6,500, the data being based upon the number of stamped envelopes used. In addition a large number of circular letters have been mailed as an adjunct to our inspection work. The larger part of the correspondence is devoted to work in connection with the inspection of fertilizers, cattle feeds, dairy apparatus and the testing of pure-bred cows. A considerable amount of time, however, is still given to answering special inquiries made by farmers and others relative to plant and animal feeding, and the composition and value of fertilizers, cattle feeds and milk.

THE FOOD VALUE OF PLAIN AND MOLASSES BEET PULP.

J. B. LINDSEY.

A few years ago[1] the writer published a brief review of the value of beet residues for farm stock. Since this publication two experiments have been made at this station comparing both the plain and molasses pulp (dried) with corn meal for milk production.

Beet pulp is the residue from the manufacture of sugar from sugar beets. After the beets are shredded and the sugar removed with water by the diffusion process, the residue is run through presses to reduce the water content and then put into kilns and thoroughly dried. The dried plain pulp is coarse and of a gray color. Molasses beet pulp is the pressed plain pulp mixed with the residuum beet molasses and dried. Another method of making the molasses pulp is to mix a definite amount of molasses with the dried pulp. It is understood that but little molasses pulp is now being made.

Composition of the Beet Pulp.

	Plain Pulp.	Molasses Pulp.	Corn Meal[2] for Comparison.	
Water,	9.08	8.48	14.99	15.60
Ash,	3.02	6.93	.86	.85
Protein,	8.90	11.16	7.88	7.82
Fiber,	18.76	10.16	.81	.80
Extract matter,	60.59	62.76	69.76	69.27
Fat,	.65	.51	5.70	5.66
Totals,	100.00	100.00	100.00	100.00

It will be noted that the plain pulp contained about 9 per cent. of water, a relatively large amount of fiber, and practically no fat. The molasses pulp contained considerably more ash, due to the large amount of mineral matter in the molasses. The fiber content was considerably less than that of the plain pulp, due to the replacing of the pulp by the molasses which was without fiber. The amount of molasses added to the pulp appears to vary more or less in different samples.

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[1] Twenty-second report of this station, Part II., pp. 21–27.

[2] Samples used in experiment.

Both the plain and the molasses pulp are carbohydrate feeds similar to corn meal, being relatively low in protein and high in carbohydrates. The extract matter of the molasses pulp contains considerable sugar, while in the plain pulp there is much less sugar and more of the hemicellulose. The carbohydrates of the corn meal consist largely of starch, while those of the plain beet pulp are made up of a high percentage of fiber together with the hemicellulose and some sugar.

Coefficients of Digestibility of Beet Pulp.

Three single trials were made with each sample of the beet pulp with the following average results: —

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Plain pulp,	75	26	52	83	83	–
Plain pulp,[1]	77	–	51	72	86	–
Molasses pulp,	82	51	61	77	90	–
Molasses pulp,[2]	85	–	64	84	91	–
Average molasses pulp,	83	51	63	80	90	–
Corn meal for comparison,	88	–	67	–	92	90

[1] German experiments.
[2] Three earlier trials.

The coefficients for plain pulp made at this station are reasonably close to those of German origin. The molasses pulp shows higher coefficients than the plain pulp. Part of this is due, however, to the high ash percentage and its increased digestibility.

Pounds of Digestible Organic Matter in a Ton.

	Protein.	Fiber.	Extract Matter.	Fat.	Totals.
Plain pulp,	92.56	311.42	1,005.79	–	1,409.77
Molasses pulp,	140.62	162.56	1,129.68	–	1,432.86
Corn meal for comparison,	105.59	–	1,283.58	101.88	1,491.05

It will be seen from the coefficients that while the dry matter in the molasses pulp has a higher digestibility than that in the plain pulp, and while the dry matter in the corn meal shows an increased digestibility over either of the pulps, the digestibility of the total organic nutrients in *one ton* of the several feeds does not vary widely. This is explained on the ground that the molasses pulp contains noticeably more ash than the plain pulp, and that the corn meal has some 6 per cent. more water than the dried pulps. On the basis of digestible organic nutrients in one ton, it would appear that the corn meal was substantially 5 per cent. more valuable than the average of the two pulps. Calculations made on the basis of net. energy value show the corn meal to furnish 20 per cent. more energy than the dried pulp. This is due to the increased energy assumed to be required to digest the fiber contained in the pulp. It is doubtful, however, if the soft beet fiber causes as much energy loss as do the harder fibers of the hays and straw. One may conclude that in practical feeding trials comparatively little difference would be noted, pound for pound, between the two feeds, especially if the amounts of each feed fed did not exceed 5 pounds daily to each animal.

Feeding Experiments with Cows.

1. *Plain Pulp* v. *Corn Meal.*

Six cows were fed by the reversal method in periods lasting five weeks.

History of Cows.

Cows.	Breed.	Age (Years).	Last Calf dropped.	Yield of Milk at Beginning of Experiment (Pounds).
Amy,	Pure Jersey,	2	September 18,	14.8
Betty,	Grade Jersey,	5	September 21,	20.8
Cecile,	Pure Jersey,	4	October 23,	27.6
Fancy II.,	Grade Jersey,	2	September 30,	14.6
Daisy,	Grade Jersey,	11	October 9,	21.5
Gladys,	Pure Jersey,	6	October 10,	22.7

Duration of Experiment.

DATES.	COWS.		Length of Period (Weeks).
	Plain Beet Pulp.	Corn Meal.	
December 4 through January 7, .	Amy, Betty, Cecile,	Fancy II., Daisy, Gladys.	5
January 14 through February 18, .	Fancy II., Daisy, Gladys.	Amy, Betty, Cecile,	5

The method of caring for, feeding and weighing the animals, of sampling the feeds and milk, was the same as described under the oat *v.* corn meal experiment published elsewhere in this report. The milk was sampled for five consecutive days on the first, third and fifth week of the experiment.

Character of Feeds. — The hay was early cut and well cured, being an admixture of Kentucky blue grass with some clover and sweet vernal grass. The corn meal and spring bran were of good average quality. Cottonseed meal was of good color, but rather below the average in protein. The plain beet pulp was of normal character.

Total Feeds consumed by Each Cow (Pounds).

Corn Meal Ration.

COWS.	Hay.	Bran.	Corn Meal.	Cotton-seed Meal.	Beet Pulp.
Amy,	546	70	105	35	-
Betty,	629	70	175	18	-
Cecile,	663	70	175	28	-
Daisy,	630	72	175	18	-
Fancy II.,	490	70	105	-	-
Gladys,	630	70	175	18	-
Totals,	3,588	422	910	117	-

Beet Pulp Ration.

COWS.	Hay.	Bran.	Corn Meal.	Cotton-seed Meal.	Beet Pulp.
Amy,	477	70	-	35	105
Betty,	625	70	-	18	175
Cecile,	663	70	-	35	175
Daisy,	628	70	-	18	175
Fancy II.,	546	68	-	-	99
Gladys,	628	70	-	18	175
Totals,	3,567	418	-	124	904

Average Daily Ration consumed by Each Cow (Pounds).

Character of Ration.	Hay.	Bran.	Corn Meal.	Cotton-seed Meal.	Beet Pulp.
Corn meal,	17.09	2.01	4.33	.67	–
Beet pulp,	16.99	1.99	–	.71	4.30

It will be seen that the different cows were fed somewhat different amounts of the several feedstuffs, depending upon their individual needs. The basal ration consisted of hay, bran and cottonseed meal to which were added an average of 4.3 pounds of corn meal or beet pulp daily. A slight error occurred in that 3.91 pounds of dry matter were fed in the form of beet pulp as against 3.70 in case of corn meal, due, of course, to the higher moisture content of the meal.

Dry Matter and Digestible Organic Nutrients in Average Daily Rations (Pounds).

Character of Ration.	Dry Matter.	Digestible Organic Nutrients.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.[1]	
Corn meal,	21.12	1.57	2.96	8.17	.53	13.87	1:7.83
Dried beet pulp,	21.29	1.54	3.53	7.60	.32	13.37	1:7.68
Haecker Standard.[2]							
Corn meal,	–	1.59	–	10.66	.46	13.26	1:7.34
Dried pulp,	–	1.60	–	10.70	.46	13.31	1:7.32
Savage Standard.[3]							
Corn meal,	–	1.97	–	–	–	14.02	1:6.12
Dried pulp,	–	1.97	–	–	–	14.07	1:6.14

[1] Including fat multiplied by 2.2.

[2] Bulletin No. 79, Minnesota Experiment Station.

[3] Bulletin No. 323, Cornell Experiment Station.

The data in the first subdivision indicate the amounts of digestible nutrients contained in the feeds actually fed. The corn meal ration contained .5 pound of total nutrients in excess of the dried beet pulp ration. The nutrients in the two rations fed agree quite closely with the Haecker standard. The Haecker standard as modified recently by Savage calls for both more protein and more total nutrients. It would probably have been advisable in case of our experiment to have reduced the basal ration of hay, bran and cottonseed meal a little in order to have secured a more pronounced effect — if any — of the corn meal and plain beet pulp. On the basis of digestible nutrients actually consumed, one would not expect much difference in the milk yield.

Herd Gain or Loss in Live Weight (*Pounds*).

Corn meal ration,	33—
Beet pulp ration,	37+

A slight difference in favor of the pulp was noted.

Yield of Milk and Milk Ingredients (*Pounds*).

Corn Meal.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (⅙ added).
Amy,	508.2	14.5	78.26	30.75	35.88
Betty,	714.1	20.4	103.33	38.20	44.57
Cecile,	901.5	25.8	127.65	46.34	54.06
Daisy,	639.4	18.3	98.21	37.34	43.56
Fancy II.,	454.8	13.0	62.22	22.06	25.73
Gladys,	723.3	20.7	105.02	40.58	47.34
Totals,	3,941.3	18.8[1]	574.69	215.27	251.14

Beet Pulp.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (⅙ added).
Amy,	482.6	13.8	72.78	28.14	32.83
Betty,	699.6	20.0	102.07	36.87	43.02
Cecile,	856.2	24.5	121.75	43.15	50.34
Daisy,	718.4	20.5	109.34	41.74	48.70
Fancy II.,	482.5	13.8	65.48	22.97	26.80
Gladys,	777.8	22.2	112.86	43.63	50.90
Totals,	4,017.1	19.1[1]	584.28	216.50	252.59

[1] Average.

The above results show no striking variations in the yields. The beet pulp ration produced substantially 2 per cent. more milk and milk solids than did the corn meal ration. This is within the limit of error. It may have been due partly to the superior mechanical effect of the pulp, although this is pure assumption.

Average Composition of the Herd Milk.

CHARACTER OF RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Corn meal, ...	14.58	5.46	9.12
Beet pulp, ...	14.54	5.39	9.15

Differences in the composition of the milk are not noted.

Food Cost of Milk and Butter.

CHARACTER OF RATION.	Total Milk.	100 Pounds Milk.	1 quart Milk (Cents).	1 Pound Butter (Cents).
Corn meal, ...	$50 80	$1 29	2.90	17.9
Beet pulp, ...	47 89	1 22	2.85	16.6

The beet pulp cost some $6 a ton less than the corn meal at the time the experiment was in progress; hence the cost of the milk produced was also less (some 6 per cent.).

Dry and Digestible Matter required to produce Milk and Milk Ingredients (Pounds).

CHARACTER OF RATION.	DRY MATTER.			DIGESTIBLE NUTRIENTS.		
	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.
Corn meal, ...	112.00	7.68	20.51	70.17	4.81	12.85
Beet pulp, ...	110.72	7.61	20.54	67.54	4.64	12.53

The above figures include the food material required for maintenance. They show that a little less dry and digestible organic nutrients were required to produce like amounts of milk and milk ingredients with the beet pulp than with the corn meal ration.

2. *Molasses Beet Pulp v. Corn Meal.*

This trial followed directly after the one with plain beet pulp already described. The same cows were used.

Duration of Experiment.

Dates.	Cows.		Length of Period (Weeks).
	Corn Meal.	Molasses Beet Pulp.	
February 26 through April 1,	Amy, Betty, Cecile,	Daisy, Fancy II., Gladys.	5
April 8 through May 13,	Daisy, Fancy II., Gladys.	Amy, Betty, Cecile,	5

Total Feeds consumed by Each Cow (Pounds).

Corn Meal Ration.

Cows.	Hay.	Bran.	Cotton-seed Meal.	Corn Meal.	Molasses Beet Pulp.
Amy,	487	70	35	105	-
Betty,	622	70	18	175	-
Cecile,	660	70	28	175	-
Daisy,	628	70	18	175	-
Fancy II.,	474	70	-	105	-
Gladys,	630	70	18	175	-
Totals,	3,501	420	117	910	-

Molasses Beet Pulp Ration.

Cows.	Hay.	Bran.	Cotton-seed Meal.	Corn Meal.	Molasses Beet Pulp.
Amy,	490	70	35	-	105
Betty,	628	70	18	-	175
Cecile,	665	70	35	-	175
Daisy,	627	73	18	-	175
Fancy II.,	398	70	-	-	105
Gladys,	630	70	18	-	175
Totals,	3,438	423	124	-	910

Average Daily Ration consumed by Each Cow (Pounds).

Character of Ration.	Hay.	Bran.	Cotton-seed Meal.	Corn Meal.	Molasses Beet Pulp.
Corn meal,	16.67	2.00	.67	4.33	-
Molasses beet pulp,	16.37	2.01	.71	-	4.33

The cows consumed slightly less hay during the molasses beet pulp half of the trial. It will be noted that hay, bran and cottonseed meal constituted the basal ration, and that 4.33 pounds of corn meal were compared with a like amount of beet pulp.

Dry Matter and Digestible Organic Nutrients in Average Daily Rations (Pounds)

CHARACTER OF RATION.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.[1]	
Corn meal,	20.90	1.50	2.83	8.22	.53	13.72	1:8.15
Molasses beet pulp,	20.98	1.59	3.15	7.86	.32	13.30	1:7.36
Haecker Standard.[2]							
Corn meal,	–	1.68	–	11.17[3]	.48	13.92	1:7.29
Molasses beet pulp,	–	1.61	–	10.68	.46	13.30	1:7.26
Savage Standard.[2]							
Corn meal,	–	2.08	–	–	–	14.73	1:6.08
Molasses beet pulp,	–	1.99	–	–	–	14.07	1:6.07

[1] Including fat multiplied by 2.2.

[2] Already cited.

[3] Fiber included.

It appears that the two rations contained substantially equal amounts of total digestible nutrients and ought to produce about the same amount of milk. The molasses pulp ration contained rather more fiber, but the excess being derived from beet pulp should not have required much more energy for its digestion than the extract matter. These nutrients fed correspond quite closely to the Haecker standard as stated above. They are not quite as liberal as those recently suggested by Savage. If the basal ration of hay, bran and cottonseed meal fed had been a little less, it would have brought out a trifle more sharply the difference — if any — in feeding value between the corn meal and the molasses pulp.

Herd Gain or Loss in Live Weight (Pounds).

Corn meal ration,	109+
Molasses beet pulp ration,	90+

A slight gain occurred on both rations, indicating that the animals were advancing in lactation and not devoting as much of their food to milk as in the former experiment.

Yield of Milk and Milk Ingredients (Pounds).

Corn Meal.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Amy, ...	595.6	17.0	90.83	35.74	41.70
Betty, ...	824.5	23.6	120.46	44.28	51.66
Cecile, ...	984.9	28.1	143.20	53.28	62.16
Daisy, ...	682.1	19.5	103.98	41.06	47.90
Fancy II., ...	370.3	10.6	50.81	18.11	21.13
Gladys, ...	726.6	20.8	104.49	40.90	47.72
Totals, ...	4,184.0	19.9[1]	613.77	233.37	272.27

Molasses Beet Pulp.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (1/6 added).
Amy, ...	481.6	13.8	72.09	28.27	32.98
Betty, ...	647.5	18.5	93 37	33.22	38.76
Cecile, ...	763.9	21.8	109.77	39.88	46.53
Daisy, ...	797.5	22.8	116.59	45.30	52.85
Fancy II., ...	496.8	14.2	71.24	25.59	29.86
Gladys, ...	867.1	24.8	125.56	48.30	56.35
Totals, ...	4,054.4	19.3[1]	588.62	220.56	257.33

[1] Average.

The herd produced some 3 per cent. less milk and 4 per cent. less solids while on the molasses pulp ration. Such results will have to be considered substantially within the limit of error. At least, no wide difference in yield is noted.

Average Composition of the Herd Milk.

CHARACTER OF RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Corn meal, ...	14.67	5.58	9.09
Molasses beet pulp, ...	14.52	5.44	9.08

The milk produced with the pulp ration appears to be slightly lower in fat than that produced by the corn meal ration. The difference is not marked and much emphasis cannot be placed upon it.

Food Cost of Milk and Butter.

Character of Ration.	Total Milk.	100 Pounds Milk.	1 quart Milk (Cents).	1 Pound Butter (Cents).
Corn meal, ...	$50 08	$1 19	2.68	16.1
Molasses beet pulp, ...	47 46	1 17	2.63	16.1

The milk produced by the beet pulp ration cost a little less because the pulp at the time could be purchased for noticeably less money per ton than the corn meal.

Dry and Digestible Matter required to Produce Milk and Milk Ingredients (Pounds).

Character of Ration.	Dry Matter.			Digestible Nutrients.		
	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.	100 Pounds Milk.	1 Pound Solids.	1 Pound Fat.
Corn meal, ...	104.40	7.12	18.72	65.35	4.45	11.72
Molasses beet pulp, . . .	108.10	7.45	19.87	66.56	4.58	12.23

The results are slightly in favor of the corn meal ration.

General Conclusions.

1. On the basis of dry matter the plain and molasses beet pulps contain substantially equal quantities of digestible organic nutrients; on the same basis corn meal has about 13 per cent. more digestible nutrients.

2. On a natural moisture basis (9 per cent. for the pulps and 15 per cent. for the corn meal) corn meal has about 5 per cent. more digestible organic nutrients than the dried beet pulps.

3. The results of the two feeding trials reported show that the rations containing the beet pulp produced substantially as much milk as those containing corn meal.

The Place of Dried Beet Residues in the Farm Economy.

Farmers who are in a position to produce their own feed cannot afford, as a rule, to purchase starchy feedstuffs; they should be produced upon the farm, in the form of corn, oats and barley. For milk production it is much more desirable to purchase materials rich in protein, such as cottonseed and linseed meals, dried distillers' and brewers' grains, gluten feed, malt sprouts, fine middlings and even bran. These feedstuffs are not only very helpful in milk production, but likewise supply large amounts of nitrogen in the resulting manure. When the supply of home-grown corn is exhausted or limited, beet residues may be substituted for fattening stock and as one-third of the grain ration for dairy purposes. Milk producers who purchase all of their grain will find the dried pulp a satisfactory component (one-third to one-half) of the daily ration. It can also be fed, in amounts of from 8 to 10 pounds of dried pulp daily, as a partial substitute for roughage. It should be mixed with two to three times its weight of water.

THE VALUE OF OATS FOR MILK PRODUCTION.

J. B. LINDSEY.

Oats are held in high esteem as a food for all classes of farm animals, and particularly for horses. They are also regarded as a valuable food for milk production, although their relative cost, especially in the east, has prevented their use for this purpose. For example, the average wholesale price for a ton of oats in 1910 was $29.51, and for the first eight months of 1911 it was $26.99, as against $26.39 and $23.88 for corn meal.

The fact that oats are so highly regarded for the production of milk led the station to conduct three demonstration experiments with dairy cows, comparing ground oats with a like amount of corn meal.

The Composition of Oats (Per Cent.).

	Oats fed.	Average American Analyses.[1]	Average Foreign Analyses.[2]	Corn Meal fed.	Corn Meal. Average Massachusetts Analyses.[3]
Water,	10.80	10.40	13.30	14.50	11.00
Ash,	3.25	3.20	3.10	.86	1.30
Protein,	12.15	11.40	10.30	7.93	9.80
Fat,	4.41	4.80	4.80	5.74	3.90
Fiber,	8.94	10.80	10.30	.81	2.00
Extract matter,	60.45	59.40	58.20	70.16	72.00
	100.00	100.00	100.00	100.00	100.00

[1] Henry, 1910.
[2] Kellner, 1909.
[3] Lindsey's Compilation, 1910.

Oats vary in composition rather more than some other cereals. The larger the percentage of hulls the lower the percentages of protein and fat. Oats that are imperfectly developed are likely to have relatively more protein and less starchy matter than those that have been well formed. The percentage of hulls varies between 20 and 35, with a probable average of 26. It was held formerly that oats contained an alkaloid avenin which accounted for their peculiar effect in imparting spirit to horses, but more recent investigations have failed to identify this product. E. Schulze identified an alkaloid Trigonellum in the oat, but the amount found was so small as to be without influence as a stimulant.

The corn meal fed in the present experiment was the usual material now offered in the general markets. It evidently was not ground corn kernels, but a sifted product resulting from the manufacture of cracked corn. The analysis of corn meal given for comparison represented the average of 119 samples of ground corn kernels. It is higher in protein and fiber and lower in fat than the sifted product.

Oats differ from corn in having noticeably more ash, rather more protein and decidedly more fiber.

THE DIGESTIBILITY OF OATS.

The coefficients of digestibility were not determined in the particular sample fed. Here follow the average coefficients obtained for American and German oats: —

	American.[1]	Foreign.[2]	Corn Meal for Comparison.
Dry matter,	70	70	88
Ash,	25	–	67
Protein,	77	76	–
Fiber,	31	26	–
Extract matter,	77	76	92
Fat,	89	80	90

[1] Lindsey. [2] Kellner.

Applying the above coefficients to the average composition of American and foreign oats, and to the average analysis for corn meal, we have the following amounts of digestible matter in 100 pounds: —

	American Oats.	Foreign Oats.	American Corn Meal.
Protein,	8.78	7.83	6.57
Fiber,	3.35	2.68	–
Fat,	4.27	3.84	3.51
Extract matter,	45.74	44.23	66.24
Total,	62.14	58.58	76.32

One hundred pounds of corn contains, therefore, some 16 pounds, or 27 per cent., more digestible material than a like amount of oats.

Kellner placed the net energy value of corn at 81.5, and of oats at 59.7, or as 100 is to 73.2 (starch equivalents). One would, therefore, assume that for the ordinary purposes of nutrition oats were substantially one-fourth less valuable than corn. This does not take into account the favorable mechanical or special energy effects of oats. The nutritive inferiority of oats is due to the large percentage of indigestible hull. The oat kernel free from hull is easily and highly digestible.

Feeding Experiments with Oats for Milk Production.

The object of the experiments was to compare a definite amount of oats with a like amount of corn meal (*a*) upon the general condition and weight of each animal and (*b*) upon the yield of milk, milk solids and fat.

The plan of the experiments consisted in taking four cows, all of which were fresh in late summer, and dividing them into two groups of two each. In the first half of the trial two of the cows received the so-called oat ration at the same time the other two cows were receiving the corn meal ration. In the second half of the trial the rations were reversed. The experiment was carried out three times.

History of the Cows, 1909–10.

Cows.	Breed.	Age (Years).	Last Calf dropped.	Yield of Milk at Beginning of Period (Pounds).
Samantha,	Grade Holstein,	6	August 18,	27.2
Minnie,	Grade Holstein,	6	August 26,	25.8
Ida,	Pure Jersey,	2	August 19,	19.3
Red III.,	Grade Jersey,	4	September 3,	27.6
May Rio,	Pure Jersey,	7	November 11,	24.2

The first four cows were used in Experiments I. and II.; cow May Rio was substituted for Minnie in Experiment III.

Duration of the Three Experiments, 1909–10.

Experiment I.

Dates.	Cows.	Ration.
October 16, through November 12,	Minnie and Samantha	Corn meal.
	Red III. and Ida.	Ground oats.
November 20, through December 17,	Red III. and Ida.	Corn meal.
	Minnie and Samantha.	Ground oats.

Experiment II.

December 25, through January 21,	Minnie and Samantha	Corn meal.
	Red III. and Ida.	Ground oats.
January 29, through February 25,	Red III. and Ida.	Corn meal.
	Minnie and Samantha.	Ground oats.

Experiment III.

March 4, through April 1,	Samantha and Red III.	Corn meal.
	Ida and May Rio.	Ground oats.
April 9, through May 6,	Ida and May Rio.	Corn meal.
	Samantha and Red III.	Ground oats.

It will be seen that each period lasted twenty-eight days with an interval of seven days between each experiment and each half.

General Care, Feeding and Weighing. — The cows were kept in roomy stalls, carded daily, and turned into the barnyard for from four to six hours each pleasant day. The daily feed was given in two portions, and water was kept continuously before each animal. All the cows were in good condition at the beginning of the trial.

Each animal was weighed for three consecutive days at the beginning and end of each half of the trial. The weighing was done in the afternoon as the cows were brought in from the yard, previous to feeding and watering.

Sampling Feeds and Milk. — The hay was sampled at the beginning, middle and end of each half of the trial. This was accomplished by taking forkfuls here and there from the day's feeding and running them through a cutter. The cut hay was mixed, subsampled, and the final sample placed in a glass-stoppered bottle and brought to the laboratory at once for a dry-matter test. An aliquot of each of the several samples of hay was mixed and analyzed. The bran, ground oats and corn meal were sampled by taking a like amount daily and placing in glass-stoppered bottles. At the end of each half of the trial a dry-matter determination was made, and at the end of three trials an aliquot of each sample was mixed and analyzed. The milk of each cow was sampled twice daily for five consecutive days on the second and fourth week of each half of the trial, preserved in glass-stoppered bottles with the aid of formalin and tested for solids and fat. The method of sampling consisted in mixing the freshly drawn milk with an especially constructed mixer, and immediately removing a definite amount with a long-handled small dipper.

Character of Feeds. — Hay, fine and early cured, largely Kentucky blue grass with more or less clover and sweet vernal grass. Ground oats, corn meal and bran of average quality.

Total Feeds consumed (Pounds).

Experiment I.

	CORN MEAL RATION.			OAT RATION.		
	Hay.	Bran.	Corn Meal.	Hay.	Bran.	Oats.
Minnie,	560	84	112	558	84	112
Samantha,	644	112	140	642	112	140
Red III.,	559	84	140	560	84	140
Ida,	501	84	112	510	81	108
Totals,	2,265	364	504	2,274	361	500
Average per cow daily,	20.22	3.25	4.5	20.30	3.22	4.46
Experiment II.						
Minnie,	544	84	112	478	84	112
Samantha,	630	112	140	554	112	140
Red III.,	553	84	140	560	84	140
Ida,	435	84	112	477	81	108
Totals,	2,162	364	504	2,069	361	500
Average per cow daily,	18.41	3.25	4.5	18.47	3.22	4.46
Experiment III.						
Samantha,	544	84	140	559	84	140
Red III.,	531	84	140	503	84	140
Ida,	448	84	112	445	84	112
May Rio,	560	84	112	553	84	112
Totals,	2,083	336	504	2,060	336	504
Average per cow daily,	18.60	3.00	4.50	18.39	3.00	4.50

It will be seen from the footings and averages of the above tables that the average basal ration in each half of each experiment consisted of like amounts of hay and bran, to which were added like amounts of either corn meal or ground oats. Hence a definite amount of corn meal was compared with a like amount of ground oats.

In the first experiment the dry matter in the corn meal and in the oats showed comparatively slight variation. In the second experiment, however, the corn meal averaged 85.37 per cent. and the oats 90.78 per cent. of dry matter, so that 3.84 pounds of dry matter in corn meal were fed against 4.05 pounds in oats. In case of the third experiment 3.8 pounds of dry matter in corn were fed against 4.02 pounds of dry matter in oats. This matter was overlooked at the time, but should have been guarded against by feeding slightly more corn meal. The difference, however, while in favor of the oats was not so great as to have caused a marked effect upon the yields of milk, and would be more than offset by the variations in the hay consumed by the several animals as indicated in the above tables.

Dry and Digestible Matter in Daily Rations (Pounds).

Experiment I.

Character of Ration.	Average Weight per Cow.	Dry Matter.	Digestible Organic Nutrients. Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
Corn meal,	877	24.61	1.63	3.40	9.63	.57	15.23	1: 8.76
Oat,	891	24.70	1.81	3.53	8.74	.52	14.60	1: 7.41

Experiment II.

Character of Ration.	Average Weight per Cow.	Dry Matter.	Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
Corn meal,	901	23.77	1.64	3.46	9.06	.56	14.73	1: 8.39
Oat,	897	23.22	1.79	3.44	8.05	.49	13.76	1: 7.02

Experiment III.

Character of Ration.	Average Weight per Cow.	Dry Matter.	Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
Corn meal,	863	23.09	1.54	3.27	8.91	.56	14.27	1: 8.71
Oat,	880	23.12	1.72	3.36	8.08	.50	13.66	1: 7.29

The total dry matter fed in the first experiment was practically identical for each ration. In the second experiment the cows averaged .55 pound more dry matter per day on the corn meal ration. This was due to the fact that cows Minnie and Samantha ate more hay while receiving the corn meal. In the third experiment the amounts of total dry matter consumed were about the same. The average amount of digestible organic matter received by each cow was from about .6 to 1 pound less per day on the oat ration, due generally to the less digestible matter in the oats, and in case of the second experiment to the less hay eaten by the two cows mentioned.

The corn ration had a wider nutritive ratio than the oat ration, due to the less protein and more carbohydrate material in the corn.

Gain or Loss in Live Weight (Pounds).

Character of Ration.	Experiment I.	Experiment II.	Experiment III.	Total Gain.
Corn meal, ...	69+	36+	57+	162
Oat, ...	85+	24—	75+	136

The above figures indicate that a gradual gain in live weight took place, particularly during the first and third experiments. In the second experiment the gain was not so noticeable and, in fact, the animals lost slightly on the oat ration. One notes, however, no particular influence of one ration over the other.

Yield of Milk and Milk Ingredients (Pounds).

Experiment I.

Character of Ration.	Total Milk.	If Corn Ration equals 100, Oat Ration equals —	Total Solids.	Total Fat.
Corn meal, ...	2,293.4	-	325.3	125.3
Oat, ...	2,146.3	93.6	302.3	118.5
Experiment II.				
Corn meal, ...	1,991.7	-	294.3	115.1
Oat, ...	2,014.2	101.2	295.1	115.6
Experiment III.				
Corn meal, ...	2,150.1	-	316.3	127.5
Oat, ...	2,234.1	104.0	324.9	131.8
Average.				
Corn meal, ...	2,148.4	-	312.0	122.5
Oat, ...	2,131.5	99.0	307.0	122.0

In the second and third experiments the yields of milk and milk ingredients were nearly identical; at least, no marked variations were noted. In the first experiment the corn meal ration apparently produced the larger yield. This, however, was due in a large measure to the fact that the cow Minnie injured a teat shortly after starting in on the oat ration, and her milk yield fell some 5 pounds per day. The most that can be said is that an average of the three trials shows the two rations to have produced substantially like results. This was at first thought hardly to be expected, for the reason that the oats contain some 30 per cent. of hull, and, other things being equal, are rated as having an inferior feeding value to the corn. It is believed that the experiments were not conducted in such a way as to bring out sharply the difference in the value of the two feeds. The animals were evidently receiving an excess of nourishment, so that the mere difference in the nutritive value between 5 pounds of corn and oats was of no particular moment. If the amount of hay and bran (basal ration) fed had been noticeably less, so that the animals would have received in addition to their maintenance requirements perhaps three-fourths of the amount of food necessary for their normal milk yield, the addition of the corn meal or oats would have given a sharper indication of their respective nutritive values.

On the basis of the method suggested by Armsby,[1] allowing .5 pound of protein and 6 therms of energy for maintenance, .05 pound of protein and .3 therm of energy per pound of 4 per cent. milk, the average cow in the three experiments required and received as follows: —

Required.

Character of Ration.	Average Weight of Cow (Pounds).	Average Milk Yield per Cow (Pounds).	Protein (Pounds).	Energy in Therms.
Corn meal,	880	19.2	1.40	11.10
Oat,	890	19.0	1.39	11.00

Received.

Corn meal,	880	19.2	1.60	12.42
Oat,	890	19.0	1.77	11.80

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[1] Farmers' Bulletin No. 346, p. 16.

The required nutrients were figured on the basis of average milk testing 4 per cent., while the average milk produced by the cows under test was 5.71 per cent. fat. Such milk would naturally require more nutrients for its production, but we have no exact method at present on which to base a calculation for milk of different degrees of richness. On the basis of the above calculations it will be seen that both the rations fed were in excess of those required, which, as above explained, would account for the lack of any particular difference in feeding effect.

The amount of digestible nutrients consumed by the *average cow,* and the amount required by Haecker's standard, was as follows: —

Nutrients consumed (Pounds).

CHARACTER OF RATION.	Protein.	Carbohydrates, and Fat multiplied by 2.2.	Total.
Corn meal,	1.60	13.82	15.42
Oat,	1.77	12.84	14.61

Haecker Standard.

Corn meal,	1.74	12.37	14.11
Oat,	1.74	12.39	14.13

It will be seen that the digestible nutrients fed in each case were noticeably above what was required.

All of the above evidence goes to show that in case of both rations the cows received more than was actually needed, which, in itself, is a reasonable explanation of why the corn did not show itself superior in nutritive effect to the oats.

Average Composition of the Herd Milk.

Experiment I.

CHARACTER OF RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).
Corn meal,	14.18	5.46
Oat,	14.09	5.52

Average Composition of the Herd Milk — Concluded.

Experiment II.

CHARACTER OF RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).
Corn meal,	14.78	5.78
Oat,	14.65	5.74

Experiment III.

Corn meal,	14.71	5.93
Oat,	14.54	5.90

Net Amount of Dry and Digestible Organic Matter Required to produce Milk, Milk Solids and Fat.[1]

Experiment I.

	100 POUNDS MILK.		1 POUND SOLIDS.		1 POUND FAT.	
	Corn Ration.	Oat Ration.	Corn Ration.	Oat Ration.	Corn Ration.	Oat Ration.
Dry matter,	68.65	71.84	4.77	5.10	12.44	13.25
Digestible organic matter,	41.55	39.91	2.89	2.83	7.52	7.35

Experiment II.

Dry matter,	71.19	68.32	4.80	4.62	12.46	11.86
Digestible organic matter,	43.24	37.84	2.91	2.56	7.55	6.55

Experiment III.

Dry matter,	65.33	62.25	4.39	4.23	10.87	10.41
Digestible organic matter,	39 54	34.36	2.66	2.33	6.58	5.74

Average.

Dry matter,	68.39	67.47	4.65	4.65	11.92	11.84
Digestible organic matter,	41.44	37.37	2.82	2.57	7.22	6.55

The above was calculated on the basis of Haecker's data, allowing 1.25 pounds of dry matter and .792 pound of digestible organic matter per 100 pounds live weight for maintenance.

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[1] Excluding food of maintenance.

The amount of total dry and digestible matter consumed was secured from our dry-matter determinations and analyses and the use of average digestion coefficients. They tell substantially the same story as did the yields of milk and milk ingredients. In the first experiment it required rather more dry matter to produce a definite amount of milk and milk ingredients with the oat ration. In all of the experiments a definite amount of milk and milk ingredients was produced by a little less digestible matter derived from the oat ration. The average of the three trials shows milk and milk ingredients were produced by the use of rather less dry and digestible matter for the oat ration. The reason for this has already been indicated.

Food Cost of Milk and Butter-fat.

Experiment I.

Character of Ration.	Total Milk.	100 Pounds Milk.	1 Quart Milk (Cents).	1 Pound Fat (Cents).
Corn meal,	$30 91	$1 35	3.04	24.7
Oat,	32 26	1 50	3.38	27.2

Experiment II.

Character of Ration.	Total Milk.	100 Pounds Milk.	1 Quart Milk (Cents).	1 Pound Fat (Cents).
Corn meal,	$30 09	$1 51	3.40	26.1
Oat,	30 62	1 52	3.42	26.5

Experiment III.

Character of Ration.	Total Milk.	100 Pounds Milk.	1 Quart Milk (Cents).	1 Pound Fat (Cents).
Corn meal,	$29 07	$1 35	3.04	22.8
Oat,	30 30	1 36	3.06	23.0

Average.

Character of Ration.	Total Milk.	100 Pounds Milk.	1 Quart Milk (Cents).	1 Pound Fat (Cents).
Corn meal,	$30 02	$1 40	3.16	24.5
Oat,	31 06	1 46	3.29	25.6

In the first experiment the milk cost noticeably less on the corn ration; in the second experiment the results were about equal; and in the third experiment the corn ration had a slight advantage. The average of the three experiments is slightly in favor of the corn ration. The reason for sharper difference between the influence of the two rations has already been explained. In this experiment hay was figured at $16, corn meal at $32, oats at $37.50 and bran at $26 a ton.

CONCLUSIONS.

1. Chemical analysis and digestion tests indicate that oats have about one-fourth less actual nutritive value than corn (on basis of equal parts of dry matter).

2. The three comparative experiments conducted with dairy cows indicated that the oat ration produced practically as much milk and butter as did the corn ration, but at 3½ per cent. greater cost.

3. The reason why the difference in the nutritive effect of the two grains was not more sharply brought out probably lies in the fact that the experiments themselves were not correctly planned. The nutritive material in the total oat ration was sufficient to enable the cows to do good if not maximum work, and the increased nutritive material in the corn ration was not necessary and had, therefore, no pronounced effect. The basal ration (*i.e.*, without the corn or oats) should have been less in amount and then the results obtained from the addition of corn and oats would have been more pronounced.

4. Many experiments to compare the practical feeding values of different feedstuffs do not return the results desired, for the reason that they are not planned in a way to eliminate all but the one point to be demonstrated. In fact, it is not believed that experiments of this character can tell as true a story as investigations resulting from analysis, digestibility and respiration experiments, when the net energy values of the several feedstuffs can be fairly accurately ascertained. Experiments however, of the sort here described are useful in giving one a general idea of the relative merits of different feeding stuffs, but care should be taken to keep the basal ration considerably below the amount of food needed, so that when the feeds to be studied are added the total ration will still be a little below the amount required by the animal for an average production.

5. While oats are a valuable food, it is not believed they can usually be fed economically to dairy animals in Massachusetts.

SOME EFFECTS OF FERTILIZERS ON THE GROWTH AND COMPOSITION OF ASPARAGUS ROOTS.

FRED W. MORSE.

A series of fertilizer experiments on asparagus was planned in 1906 by Director Brooks, to ascertain the efficiency of different methods of manuring this crop. The field is located on the farm of Mr. C. W. Prescott in Concord, and its soil is like that of most asparagus fields, a sandy loam of little natural fertility.

In January, 1910, the writer was assigned the task of ascertaining the specific effects of the three principal chemical fertilizers used in the experiment — nitrate of soda, acid phosphate and muriate of potash — on the chemical composition of the crop, as such effects would be important factors in determining the relative efficiency of the fertilizers.

This paper will deal with the effects of the fertilizers upon the roots of the asparagus plants, a matter about which little has been reported by other workers.

Rousseaux and Brioux made a partial analysis of the roots as a minor part of an elaborate research on the asparagus crop published in 1906.[1]

Tanret has made an extended study of the properties of the carbohydrates contained in the roots.[2]

Wichers and Tollens have reported very complete analyses of roots collected before and after the cropping season.[3]

The material studied by the writer consisted of the entire underground portion of the asparagus plant, except the fine, fibrous feeding-rootlets which were removed, as it was impossible to collect any reasonable proportion of them.

No effort was made to separate the crown or center of the plant from the fleshy roots. The plants were selected by the size of their tops, and the effort was made to get average plants for each type of fertilization. The plants were carefully excavated, and as nearly as possible all the fleshy roots were collected. In some instances growth had been so extensive that adjacent roots were much interlaced, and it was impossible to secure one plant without destroying all others around it. Therefore, our largest, heaviest roots were more or less incomplete.

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[1] Annales de la Science Agronomique, 3d Series, I., pp. 189–326 (1906).

[2] Bulletin de Soc. Chim. (4) V., pp. 889–893 (1909); Compt. Rend. 149, p. 48 (1909).

[3] Jour. fur Landwirthschaft 58, pp. 101–112 (1910).

On the day following the collection of the specimens the roots were shipped from Concord to the experiment station, where they were placed in a cool cellar. The process of washing free from soil, weighing when free from surface moisture, drying and grinding, was very laborious and required several weeks, owing to the weight and bulk of the material. There is always danger of respiratory changes during the period of preparation, between collecting and drying; but it is believed that they were reduced to a minimum by keeping the roots in a cool place at about 10° C. Washing was performed within a few days after digging, and the weights of the fresh roots were obtained before there could have been any respiratory losses.

The material was prepared for drying by passing the crown and roots through a hand-lever fodder-cutter by which they were cut into pieces about 2 centimeters in length. Drying was done in a large oven at a temperature between 50° and 60° C., and the material was dried until sufficiently brittle to be easily ground. The weight of the specimen was taken at this stage, and then the entire lot was coarsely ground in a drug-mill, after which it was sampled by quartering and the sample reduced to a powder which would pass though a 1 millimeter mesh sieve. Moisture determinations were then made in the powdered samples, from which were calculated the weights of absolutely dry matter contained in the specimen roots.

Three different series of samples have been studied during this investigation.

The first series consisted of 44 roots, or 4 specimens from each of 11 plots, used for testing different quantities and different seasons of application of nitrate of soda. They were collected in November, 1908, two years after the field had been set with plants, by Mr. E. F. Gaskill of the agricultural department of the experiment station, and were prepared for analysis in part by the fertilizer section and in part by the feed and dairy section of the department of chemistry.

The second series consisted of 76 roots, or 4 from each of 11 nitrogen plots before mentioned, together with 4 plots used for a test of different quantities of superphosphate and 4 plots for different quantities of muriate of potash. These samples were secured by Mr. Gaskill and the writer in November, 1910, and were prepared for analysis under the supervision of the latter.

The third series consisted of 16 roots, or 4 from each of 4 of the nitrogen plots, and were gathered under the supervision of Mr. C. W. Prescott on June 23, 1911, and were prepared for analysis by the writer.

All the analytical work has been based on the methods of the Association of Official Agricultural Chemists,[1] except where departures are mentioned as necessary owing to the character of the material.

AMOUNT OF FERTILIZERS APPLIED.

Each plot in these tests contained one-twentieth acre and was 129 feet long by 16 feet 10½ inches wide. At the time of setting the plants the entire area received a uniform dressing of the following chemical fertilizers: —

	Pounds per Acre.
Lime,	2,000
Fine-ground bone,	1,000
Nitrate of soda,	150
Acid phosphate,	600
Muriate of potash,	350

No check plots without fertilizer were included in the plan.

The annual top-dressing was applied to the different plots in the following quantities per acre: —

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[1] Bulletin No. 107 Revised, Bur. of Chem., U. S. Dept. of Agr.

	Plot Number.	Nitrate Soda (Pounds).	Acid Phosphate (Pounds).	Muriate Potash (Pounds).
No nitrate,	1, 40	-	200.1	260.0
Low nitrate,	31, 32, 33	311.2	200.1	260.0
Medium nitrate,	34, 35, 36	466.6	200.1	260.0
High nitrate,	37, 38, 39	622.4	200.1	260.0
No phosphate,	5	466.6	-	260.0
Low phosphate,	6	466.6	133.4	260.0
Medium phosphate,	7	466.6	200.1	260.0
High phosphate,	8	466.6	266.8	260.0
No potash,	9	466.6	200.1	-
Low potash,	10	466.6	200.1	173.4
Medium potash,	11	466.6	200.1	260.0
High potash,	12	466.6	200.1	346.8

The nitrate of soda was applied to plots 31, 34 and 37 in the spring before growth began; to plots 32, 35 and 38 in the summer after cutting had ceased; and to plots 33, 36 and 39, one-half in spring and one-half in summer. All phosphate and potash salts were applied in the spring.

EFFECT OF FERTILIZERS ON THE WEIGHT OF ROOTS.

Since the marketable crop from the asparagus plant must be grown almost entirely at the expense of the reserve plant food stored in the crown and roots, the size of the roots at the beginning of the growing season would seem to be an important factor in the yield of sprouts. While their relationship has not yet been determined, it has been noted that the different top-dressings influenced the size of the roots to a marked extent.

The effects of nitrate of soda have been observed in all three series of samples, but only one series has afforded an opportunity to study the effects of phosphates and of potash salts. Nevertheless, the series gathered in 1910 was at the end of the fourth season of growth, and hence should have the cumulative effect of three annual dressings.

Effect of Different Amounts of Nitrate of Soda.

Season of 1908, Average Roots.

	Plot Number.	Fresh Weight (Grams).
No nitrogen,	1, 40	1,027
Low nitrogen,	31, 32, 33	947
Medium nitrogen,	34, 35, 36	1,248
High nitrogen,	37, 38, 39	1,127

Season of 1910, Average Roots.

	Plot Number.	Fresh Weight (Grams).
No nitrogen,	1, 40	2,128
Low nitrogen,	31, 32, 33	2,362
Medium nitrogen,	34, 35, 36	2,703
High nitrogen,	37, 38, 39	2,464

Season of 1911, Average Roots.

	Plot Number.	Fresh Weight (Grams).
Low nitrogen,	31, 32	2,259
Medium nitrogen,	34, 35	2,555

It is noted that the medium application of nitrate of soda has produced the heaviest average roots in each season.

Effect of Phosphate and Potash Salts.

Season of 1910, Average Roots.

	Plot Number.	Fresh Weight (Grams).
No phosphate,	5	1,783
Low phosphate,	6	2,853
Medium phosphate,	7	2,735
High phosphate,	8	2,246
No potash,	9	1,674
Low potash,	10	2,395
Medium potash,	11	2,893
High potash,	12	2,709

In spite of the large application of bone, acid phosphate and muriate of potash at the time of setting the plants, the absence of either in the top-dressing produces a notably lower average weight of roots. The medium applications of phosphate and of potash salts produce the highest average weights of roots.

Rousseaux and Brioux[1] found the heaviest roots where manure and chemicals were combined, and it is of interest that the fresh weight was 2,600 grams, which is practically the same as the weight of our roots from the plots receiving top-dressings of medium amounts of fertilizers.

Effect of Season of Application of Nitrate of Soda on Weight of Roots.

Spring Application (Grams).

	Plot Number.	1908.	1910.	1911.
Low,	31	1,025	2,545	1,852
Medium,	34	1,260	2,733	2,776
High,	37	1,336	2,854	-
Average,	-	1,207	2,711	2,314

Summer Application (Grams).

Low,	32	923	2,004	2,666
Medium,	35	1,274	2,289	2,335
High,	38	1,302	2,311	-
Average,	-	1,166	2,201	2,501

Spring and Summer Applications (Grams).

Low,	33	895	2,538	-
Medium,	36	1,211	3,089	-
High,	39	730	2,227	-
Average,	-	945	2,618	-

The summer top-dressing with nitrate has produced smaller mature roots than the spring top-dressing, in both years 1908 and 1910. On the other hand, the roots of 1911, taken at the end of the cutting season in the summer, show variable results, with the average weight heavier on the summer-dressed plots.

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[1] *Loc. cit.*, p. 312.

The individual roots in this summer collection showed much wider variations than the late fall series, which is attributed to the difficulty of judging average plants by the young shoots, and it is probable that the different plots are not as fairly represented as in the fall collections.

EFFECT OF FERTILIZERS ON THE FERTILIZING CONSTITUENTS OF THE ROOTS.

The fertilizing constituents of asparagus roots were found by Rousseaux and Brioux[1] to be as follows: —

	Manure only (Per Cent.).	Manure and Chemicals (Per Cent.).
Dry matter,	28.26	26.27
Ash,	6.90	7.22
Nitrogen,	1.20	1.73
Phosphoric acid,	.50	.48
Potash,	1.23	1.57
Lime,	.31	.41
Magnesia,	.04	.05
Sulfuric acid,	.33	.36

Wichers and Tollens[2] reported the following results on the principal fertilizing constituents: —

	Roots (Per Cent.).	Crown (Per Cent.).
Moisture,	3.00	3.86
Nitrogen,	2.26	1.64
Phosphoric acid (P_2O_5),	.89	.54
Potash (K_2O),	1.44	1.60

The general average of fertilizing constituents calculated from the various analyses made at this experiment station is as follows: —

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[1] *Loc. cit.*, p. 312.

[2] *Loc. cit.*, p. 109.

	Per Cent.
Dry matter,	21.68
Ash,[1]	6.56
Nitrogen,	1.95
Phosphoric acid (P_2O_5),	.48
Potash (K_2O),	2.36
Lime (CaO),	.34
Soda (Na_2O),	.30
Magnesia (MgO),	.17
Sulfuric acid (SO_3),	.56

An interesting fact shown by this table is the higher average percentage of sulfuric acid over that of phosphoric acid. The proportions of fertilizing constituents were varied somewhat by the applications of different quantities of the chemical fertilizers, as is usually observable in similar experiments with crops.

Effect of Nitrate of Soda on Ash Constituents.

Roots of 1908.

	No Nitrate, Plots 1 and 40.	Low Nitrate, Plots 31, 32, 33.	Medium Nitrate, Plots 34, 35, 36.	High Nitrate, Plots 37, 38, 39.
Ash,	5.73	6.40	6.69	6.59
Phosphoric acid,	.47	.53	.47	.51
Potash,	2.27	2.33	2.46	2.54
Lime,	.30	.28	.32	.34
Soda,	.07	.20	.27	.26
Magnesia,	.13	.14	.15	.15
Sulfuric acid,	.39	.48	.52	.52

Effect of Superphosphate on Ash Constituents.

Roots of 1910.

	No Phosphate, Plot 5.	Low Phosphate, Plot 6.	Medium Phosphate, Plot 7.	High Phosphate, Plot 8.
Ash,	6.81	7.09	7.54	7.34
Phosphoric acid,	.47	.46	.46	.49
Potash,	2.36	2.66	2.73	2.54
Lime,	.41	.32	.37	.38
Soda,	.43	.35	.38	.33
Magnesia,	.18	.16	.21	.19
Sulfuric acid,	.69	.62	.68	.63

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[1] Ash determinations and all ash analyses were made in the fertilizer section by Mr. H. D. Haskins and Mr. L. S. Walker.

Effect of Muriate of Potash on Ash Constituents.

Roots of 1910.

	No Potash, Plot 9.	Low Potash, Plot 10.	Medium Potash, Plot 11.	High Potash, Plot 12.
Ash,	5.94	6.17	6.18	7.10
Phosphoric acid,	.44	.42	.46	.48
Potash,	1.44	2.10	2.20	2.53
Lime,	.38	.33	.34	.40
Soda,	.55	.48	.33	.33
Magnesia,	.19	.18	.19	.20
Sulfuric acid,	.66	.57	.62	.62

The presence or absence of phosphoric acid in the top-dressing produces little or no perceptible effect on the ash and ash constituents, even the phosphoric acid percentages being remarkably uniform throughout the whole series of tests. The absence of nitrate of soda and muriate of potash reduces the percentages of ash, and in the former case the soda and sulfuric acid are reduced also, while in the latter case it is the potash which is reduced. Lime and magnesia are apparently unaffected by the variations in top-dressings.

EFFECT OF FERTILIZERS ON THE NITROGEN AND NITROGENOUS RESERVE MATERIAL.

The nitrogenous matter stored in the roots was definitely affected by the different quantities of nitrate of soda applied, and also by its season of application; but the superphosphate and muriate of potash had no effect on the percentage of this element.

Effect of Nitrate of Soda on Nitrogen.

	Plot Number.	1908 (Per Cent.).	1910 (Per Cent.).
No nitrate,	1, 40	1.28	1.53
Low nitrate,	31, 32, 33	1.69	1.82
Medium nitrate,	34, 35, 36	2.10	1.97
High nitrate,	37, 38, 39	2.10	2.05

Effect of Superphosphates on Nitrogen.

	Plot Number.	1910 (Per Cent.).
No phosphate,	5	2.27
Low phosphate,	6	2.05
Medium phosphate,	7	2.18
High phosphate,	8	2.04

Effect of Muriate of Potash on Nitrogen.

	Plot Number.	1910 (Per Cent.).
No potash,	9	2.10
Low potash,	10	2.02
Medium potash,	11	2.06
High potash,	12	2.08

Effect of Season of Application of Nitrate of Soda on the Nitrogen.

Spring Application.

	Plot Number.	1908 (Per Cent.).	1910 (Per Cent.).
Low,	31	1.57	1.64
Medium,	34	2.18	1.97
High,	37	1.96	1.96
Average,	–	1.90	1.86
Summer Application.			
Low,	32	1.78	1.99
Medium,	35	2.23	2.01
High,	38	2.36	2.22
Average,	–	2.12	2.07
Spring and Summer Applications.			
Low,	33	1.73	1.82
Medium,	36	1.92	1.94
High,	39	1.98	1.98
Average,	–	1.88	1.91

The higher percentage of nitrogen due to the summer top-dressing with nitrate of soda is very noticeable, as was the smaller average weight of roots, compared with the spring application.

The roots of 1911 gathered in the summer just before the annual summer top-dressing showed the same general differences between the spring top-dressing and summer top-dressing.

Spring Application.

Plot Number.	Per Cent.
31,	1.81
34,	2.05
Average,	1.93

Summer Application.

Plot Number.	Per Cent.
32,	2.06
35,	2.15
Average,	2.10

Whatever exhaustion of material occurred during the cutting season did not influence the percentages of nitrogen in the roots.

EFFECT OF FERTILIZERS ON THE NON-NITROGENOUS MATERIAL OF ASPARAGUS ROOTS.

Wichers and Tollens [1] have shown the proximate composition of asparagus roots and crowns to be as follows: —

	April.		July.	
	Roots.	Crowns.	Roots.	Crowns.
Moisture,	3.00	3.86	3.61	2.93
Ash,	12.20	15.21	11.77	11.67
Crude protein,	14.13	10.25	16.56	9.90
Crude fiber,	8.72	15.42	13.54	19.79
Fat,	.72	1.59	1.10	1.67
Nitrogen-free extract,	61.23	53.67	53.42	54.04
	100.00	100.00	100.00	100.00
Sugar,	36.80	17.70	23.19	15.32
Pentosans,	6.25	9.77	7.73	11.48

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[1] *Loc. cit.*, p. 109.

The writer has found the composition of the combined crowns and roots in his samples to average as follows: —

	November, 1908, 16 Roots.	November, 1910, 4 Roots.	June, 1911, 8 Roots.
Dry matter,	-	22.40	18.34
Ash,	6.24	7.68	8.87
Crude protein,	11.03	11.02	12.75
Crude fiber,	15.39	17.89	23.66
Fat,	1.00	1.58	1.63
Nitrogen-free extract,	66.34	61.83	53.09
	100.00	100.00	100.00
Sugar,	41.43	35.85	20.87
Pentosans,	8.78	10.12	11.66

The sugar which forms such an important percentage of the reserve material has been found to be a soluble carbohydrate readily hydrolyzed to glucose and fructose, having a rotary power differing widely from cane sugar, but otherwise resembling it in all its chemical properties.[1]

In the series of 1910 and that of 1911 particular attention was paid to the sugar to determine if fertilizers had any effect on its development.

The sugar was extracted by heating 2 grams of the dry, finely powdered material with 50 cubic centimeters of water in the boiling water bath. Basic lead acetate and alumina cream were added after the solution was cool, and the volume made up to 100 cubic centimeters. When the precipitate had settled, which it usually did in an hour, the solution was filtered through a dry filter. The lead was then removed with sodium carbonate and an aliquot of 50 cubic centimeters was inverted by HCl by standing for twenty-four hours at 20° to 25° C.

About half of the samples showed the presence of reducing sugars before inversion, but seldom more than a trace; the remainder showed no presence of reducing sugars

The total invert-sugar was determined by use of Fehling's solution in the usual manner, and the copper was determined volumetrically.

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[1] Tanret, *loc. cit.*; Wichers and Tollens, *loc. cit.*; Morse, Jour. Am. Chem. Soc., 33, 211–215.

In the nitrogen series the sugar was determined in each root and then averaged for the plot as in the nitrogen investigation, but in the superphosphate and potash series only two roots from each plot were used.

Effect of Nitrate of Soda on Sugar.

No Nitrate.

	Plot Number.	1910 (Per Cent.).	1911 (Per Cent.).
	1	29.80	–
	40	37.41	–

Low Nitrate.

Spring application,	31	35.76	25.76
Summer application,	32	29.79	13.30
Spring and summer application,	33	31.85	–

Medium Nitrate.

Spring application,	34	34.56	27.84
Summer application,	35	38.56	25.90
Spring and summer application,	36	31.59	–

High Nitrate.

Spring application,	37	35.48	–
Summer application,	38	36.04	–
Spring and summer application,	39	34.43	–

Effect of Superphosphate and Muriate of Potash on Sugar.

	Plot Number.	1910 (Per Cent.).
No phosphate,	5	26.02
Low phosphate,	6	25.89
Medium phosphate,	7	28.05
High phosphate,	8	24.86
No potash,	9	28.72
Low potash,	10	32.56
Medium potash,	11	32.10
High potash,	12	34.79

The percentages of sugar vary independently of the various kinds of top-dressing, since there are wide variations in the results for Plots 7, 11 and 34, on which identical amounts of fertilizers had been applied.

The season of application of nitrate of soda apparently did not influence the percentages of sugar in the fall roots, but there is less apparent exhaustion in the 1911 roots where nitrate had been applied in the spring (Plots 31 and 34).

Since the variations in sugar showed so little relationship to the scheme of fertilization, it was not deemed worth while to pursue the investigation into the effects upon fiber and pentosans, as there are too many factors to be correlated.

Summarizing the results briefly, it has been shown that the medium amounts of chemicals in this series of fertilizer tests produced the most favorable results on size and composition of the asparagus roots.

The absence of any one of the three fertilizers resulted in depression of weight of root, which was accompanied by a depression in nitrogen in the absence of nitrate of soda, and by a depression in the potash and ash in the absence of muriate of potash.

The summer top-dressing with nitrate of soda produced smaller roots than the spring top-dressing, but with notably higher percentages of nitrogen. The exhaustion of the roots by the cropping season was most manifest in the percentages of sugar in the roots from the summer top-dressed plots.

The thanks of the author are due Messrs. Haskins and Walker for the analytical data on ash and ash constituents, to Dr. W. P. Brooks, director, for the fertilizer data, and to Dr. J. B. Lindsey, chemist, for many timely suggestions.

DEPARTMENT OF ENTOMOLOGY.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD.

During the year 1912 the work in the department of entomology has been mainly devoted to the prosecution of projects already begun, with few additions to the list.

The insect collection has been somewhat added to and maintained in its previous good condition. Its constant use for reference by every one working on insects at the college, and by many from outside, has been very noticeable, and its value for this purpose is constantly increasing as it becomes more complete.

The number of letters of inquiry received during the year has been so large as to require, on an average, several hours' attention each day, and, as was the case last year, has covered many topics. Most of these inquiries have not been about the more noticeable insects, but about what may be termed those of secondary prominence, for though destructive they are not as liable to attract attention. As less is naturally known about these insects than about the more evident ones, more time has necessarily been required to give the information desired than was the case a few years ago, and in some instances personal visits have been required in order to fully understand conditions before the best advice as to treatment could be given.

Under the Hatch act further observations on the dates of hatching of the young of the oyster-shell, pine-leaf and scurfy scales have been made, and experiments on the control of the onion maggot have been begun. These last are reported on more fully elsewhere. Tests of various insecticides have been made and are also reported elsewhere. Methods for the protection of seed corn from wireworms have been continued, and an improvement on those previously discovered is now under consideration for next season.

Under the Adams fund the two projects mentioned in former reports have been carried farther. The causes of the burning of foliage by arsenical poisons have been given much study, accompanied by over a thousand separate field tests, each followed by an examination of the results of the treatment at intervals of a day or two for more than a month. Closely involved in this has been the consideration of the nature of the insecticides used, and in this portion of the work the co-operation of the chemical department of the station has been invaluable.

If the causes of injury to foliage following the application of arsenicals are to be clearly understood, it is evident that the composition of the materials applied must be known. The injury may in fact be due, either to impurities in the materials themselves, to their decomposition after application to the leaves, or to something normally and necessarily present in them. To avoid the first possibility, materials as nearly absolutely pure as it is possible to obtain have been sought, and have only been found after many trials, it being evident that almost none of the insecticides on the market at the present time are pure or even anywhere near it. As it is quite possible that the impurities are the cause of the injuries, it is of course desirable to eliminate these, and in the materials used the first season it was supposed that this had been accomplished. Too late it was learned that this was not the case, and that the treatment was made with substances which had been guaranteed pure by the manufacturers, but which were far from being so. The consequence was that the chemical department was obliged to take up the problem of finding methods by which pure Paris green, arsenate of lead and arsenate of lime could be made, and of providing this department with them in quantities sufficient for use. This has been successfully accomplished, and the spraying last year, in part, and the past summer has been with these.

The actual value of wasps as parasites has never been investigated carefully. General statements that they are "extremely useful," or that "their importance can hardly be overestimated," are in reality little more than guesses, and it has seemed desirable to investigate the subject more scientifically in order to determine their real efficiency. To do this with all wasps is of course impossible, so a group of these insects widely distributed in all parts of the country has been selected for study. To clear the way and establish a firm foundation for the work it has been necessary to ascertain how many kinds are involved, and their relative abundance in different localities, to be followed by a determination of their fertility, the nature and amount of the food they consume, their mortality and numerous other factors which enter into the problem. Most of the preliminary work on this project has now been completed, and considerable has been accumulated on its other aspects. It is too soon to generalize on this subject, but it has already become evident that these insects are decidedly beneficial because of their choice of food material which is in most cases chosen from among our worst pests.

The results of experimentation on color vision in bees — an Adams fund project in charge of the apiarist of the station — are stated as follows: —

> While much limited in time available for the several branches of bee-keeping work this year, progress in experimentation on the color vision of bees has been made. One supposition has been proven with relative satisfaction. An instrument for counting has been devised and relatively perfected. A foreign work which applies to the problem has been translated. Correlated experiments have given and are giving good results.

So far as opportunity has offered, studies on the distribution of our worst pests in the State have been continued and the results tabulated for future reference.

Other work of the department is more fully detailed elsewhere in this report under the titles, "Tests of Insecticides," "Experiments for the Control of the Onion Maggot" and "Insect Record for 1912 in Massachusetts."

EXPERIMENTS FOR THE CONTROL OF THE ONION MAGGOT.

H. T. FERNALD AND A. I. BOURNE.

Onions are grown on a large scale in many parts of Massachusetts, particularly in the Connecticut valley. Fields covering 10, 15 or even 25 acres are common, and the crop is an important one.

For some years the onion maggot, *Phorbia cepetorum* Meade, has been a serious enemy of the onion grower in this region, much loss having been caused by its ravages. In 1911 this was particularly the case, one individual who had 6 acres planted estimating his loss by the attacks of this insect at about $400. Quite a part of this was on one plot covering only 2 acres, which was so thoroughly infested as to make the crop there hardly worth gathering. It has seemed desirable on this account to investigate methods for the control of the onion maggot, particularly as applied to large fields.

The Problem.

1. To determine the effectiveness of various methods for the control of the onion maggot.

2. To determine whether any which prove effective can be used in large fields without too great cost.

Previous Experiments.

An examination of the literature on this subject showed that most of the work had been primarily with other maggots such as the cabbage maggot, *Pegomyia brassicae* Bouché, and that conclusions had apparently to a large extent been drawn from these experiments. Where this was not the case it seemed probable from what was stated that the tests had been made upon but a few rows of onions at most.

To regard methods of controlling the cabbage maggot as equally applicable to the onion maggot is a rather doubtful position to take. Cabbages are grown from seed under glass or screens, and when they have arrived at the proper size are transplanted; and are usually placed about 2 feet apart. Onions (except for "sets") are planted where they are to remain until gathered, only an inch or two apart, and with the rows from 12 to 15 inches distant. Conditions, therefore, are widely different, especially when a large acreage is concerned.

With these facts in mind some of the treatments described could immediately be discarded as impracticable under the conditions existing, whether reported as of value or not. Others, it seemed, might possibly be made use of, — though the question of their cost for large fields would need to be determined, — while others, still, appeared on their face to be rather promising. A new substance, nicine, which had been received for trial was also included in the list of materials to test.

Conditions of the Experiment.

For experimental purposes on a rather small scale, preliminary to later, more extended ones, two plots of land were reserved close by where onions had been growing the preceding year, and where the maggots had been very abundant. Each was about 70 by 75 feet in dimensions. The north plot lay somewhat higher than the other, and the soil was somewhat sandy and lighter than that of the south plot, where it was rather heavy. Both plots sloped slightly toward the south, and the two were separated only by a grass roadway. In the north plot the onions were planted in rows about a foot and a half apart, while in the other they were only a little over a foot apart. In both plots the rows ran north and south.

The "catch" of the seed in neither plot was satisfactory. Gaps often a foot or two in length were frequent in the rows, particularly in the north plot, and this may have had some influence upon the results, as it is claimed that the maggots after destroying a plant may at least in some cases pass to the next one in the row. If this be correct, gaps in the row would tend to reduce the number of plants injured below what would be the case in full rows.

Treatment was begun soon after the plants appeared, when they were not more than an inch and a half high, and was continued at proper intervals until the maggots were seen to be leaving the plants to pupate. At the time of the first treatment no trace of maggots or of flies laying eggs could be found. Each material was applied to specified rows in each plot. Between these, untreated rows — usually several — were reserved as checks.

The weather during the period the tests were made was, on the whole, quite favorable, there being little rain, and what there was, mainly in the form of light showers. In no case did rain follow an application so closely as to thereby much impair its effectiveness. Occasionally the wind was strong enough to cause a little difficulty in applying dusting materials, but in general the days were clear, warm to hot, and with little wind.

Examination of the results of each kind of treatment was made frequently, and all plants found infested were removed, care being taken to remove all the maggots at the same time, that they might not go to other plants and thereby increase the apparent infestation.

No exact record of the number of maggots found in any single plant was kept, but it was noticed that during the earlier part of the season there were usually but one or two maggots in each infested plant. Later, as the plants became larger, it was not uncommon to find 10 or 12, or even more, in a plant. Wireworms and white grubs were present, attacking the onions, but in very small numbers.

Experimental Work.

Examination of the records of work on this insect carried on elsewhere finally resulted in the selection of the following materials for trial: (1) carbon disulfid; (2) nicine; (3) powdered hellebore; (4) hellebore decoction; (5) soap wash; (6) carbolic acid and lime; (7) kerosene emulsion of three different strengths; (8) carbolic acid emulsion also of three different strengths. More detailed accounts of the use of each of these, and the results, follow: —

Carbon Disulfid. — This substance has been recommended as very effective. It is applied in shallow grooves near the plants, so that the gas into which it becomes converted may penetrate through the soil to the onions and destroy the maggots. The fluid itself, however, is liable to kill the plants if it reaches them.

In this experiment a shallow groove was made about 2 inches from each plant, and a little of the liquid was poured into this. The groove was then quickly covered. The application is rather slow and tedious, particularly if more than a small area is thus treated, as the grooves must be short, unless considerable material is wasted, in order to cover quickly.

This treatment proved to be very unsatisfactory. For some reason many of the plants were killed, indicating that either too much disulfid was applied; that the grooves were too near the plants; or that the gas as well as the liquid is dangerous to use. In this experiment about 90 per cent. of the plants died. On the other hand, a large proportion of the plants which escaped destruction by the treatment became infested with maggots, from which it may be concluded that where the application is so far from the plant or so little is used as to avoid injury no protection from maggots is obtained. It is possible that with an exact amount of material to apply to each plant carefully worked out, and the distance to apply this also known, protection without injury might be secured; but it is evident that such care in application as this would require would be impossible in the case of large fields, where the amount of time demanded to do it properly would make the cost prohibitive.

Even when not applied with the utmost care the cost is great. Carbon disulfid in small quantities costs about 30 cents per pound. It might, perhaps, be obtained in bulk for half this price, but taking the higher cost and calculating the amount necessary to treat 1 acre we would have an expenditure of from $12 to $14, while the time required to apply it to this area, based on wages at $1.75 per day, would be rather more than this, and if more care in the application were given the time would probably be more than doubled. The cost of using carbon disulfid per acre, therefore, allowing the material to be purchased at half what it actually cost for the experiments, would be at least from $20 to $30 per acre, — a prohibitive expense.

Nicine. — This substance, manufactured by the Hood Chemical Company of Chicago as a deodorant, disinfectant and germicide, was offered for trial as an insect repellant. It is a powder, and directions furnished by the company were as follows: —

> Where a plant or tree is infected with root maggots shake off as much of the earth from the roots as possible. Then sprinkle nicine over the roots and plant in fresh soil, and if convenient make a small circular ditch about 3 or 4 inches deep around the plant and 1½ to 2 feet from the center. Sprinkle nicine freely in this ditch, cover up with soil, and the plants will not be bothered with maggots or insects.

It was manifestly impossible to follow these directions in the case at hand. The nicine was therefore dusted along the rows, care being taken to place a good supply around the base of each plant. As the maggot must work down along the plant to the bulb, where it feeds, this method would seem to force the maggots to pass through, or at least close to, the powder, which has a very pronounced odor.

The result of this experiment was unsatisfactory, as plants in the rows treated became infested shortly after the application. In fact, some of the earliest infestations in the field were in rows treated in this way.

At such prices as have been quoted for this material, enough to treat an acre in this way would cost about $50, and the labor in applying it would cost about $12 or $13. Evidently, then, this material is not available for use on large onion fields, irrespective of its effectiveness, because of the expense which would be incurred.

Powdered Hellebore. — Ordinary powdered hellebore was dusted liberally along the rows around and over the bases of the plants, with the idea that the young maggots working down to the bulbs to feed would come in contact with it and be destroyed. It has been supposed that it might also act to some extent as a repellant, preventing egg laying.

Results from this treatment could at best be rated as only fair. The application was repeated three times, and this of course meant a large increase in cost. Hellebore in sufficient amount to treat an acre once would cost, at the rate paid for the material used in these tests, more than $50, and the labor in applying it about $13 more. Even if it were effective as a treatment its cost would, accordingly, prevent its use in large onion fields.

Hellebore Decoction. — This was prepared in accordance with directions given by Smith (New Jersey Bulletin No. 200), by steeping 2 ounces of powdered hellebore in a quart of water for half an hour, stirring occasionally. It was then diluted, to make 1 gallon of liquid, and applied thoroughly to the ground at the base of each plant. If a large amount of this decoction be made at one time it can be kept without losing strength if placed in tight containers.

This material was applied through a nozzle giving a coarse stream, only enough pressure being given to the pump to cause a steady flow, without breaking up the decoction into a spray. A liberal amount was placed at the base of each plant in this way. Three applications were made at about ten-day intervals.

Results obtained were very unsatisfactory, as the treatment did not seem to have any effect whatever on the infestation. Its cost, too, though less than that of the powdered hellebore, placed it as too expensive for use. Decoction sufficient for one application to an acre would cost about $15, while the expense of application would be about $12. Three treatments, therefore, would be prohibitive from this standpoint, though necessary, even according to those who report some success with this material.

Soap Wash. — This was made by dissolving 1 pound — about 2 bars, in most cases — of good soap in 10 gallons of water. It was poured along the rows, using a force pump without a nozzle so that a solid stream could be obtained, and the ground around the plants was well soaked with it. Three treatments were given at intervals of about ten days except in one case where rain seemed to make it desirable to repeat the application without waiting for the end of this period.

Results with this material were at best only moderately good, infection appearing to some extent along the rows treated in this way. As the cost of soap enough to cover an acre once in this way would be from $8 to $10, and the labor involved would come to about $14, three treatments, each costing from $20 to $24, would manifestly be too expensive.

Carbolic Acid and Lime (*"Carbolized Lime"*). — The object of this treatment is to cover the ground around each plant with a coating through which the maggots cannot penetrate, much as tarred paper discs act in the case of the cabbage maggot. The practical difficulty with it is that in cultivation and weeding the coating becomes broken and therefore not effective.

To prepare it, lime is slaked to a thick cream. Three pints of this are added to a gallon of water, and a tablespoonful of crude carbolic acid is stirred in. The mixture is then poured along the rows to form a complete coating around each plant.

The odor of the carbolic acid was very noticeable for some time near the plants treated in this way. It was necessary to repeat the treatment, however, after each cultivation or row weeding, as in every case the coating was more or less broken by this work.

The results were far from satisfactory. Either the coating was not sufficiently thick to prevent the maggots from passing through it, or they went beneath it. In any case, the infestation in the rows treated with this material was as great as in the check rows.

The cost of the material was not great, nor was the time necessary to prepare it. Application, however, had to be carefully made, and the total cost per acre for a single treatment would be about $23 or $24. At least three applications would be necessary following cultivation, which would make this treatment too expensive.

Kerosene Emulsion. — This material was prepared according to the usual formula, and was diluted to three different degrees: 1 part of stock emulsion to 9, 1 to 14 and 1 to 19 parts of water. It was applied in the same way as the soap wash and repeated at intervals of from ten to fourteen days. No injury to the plants at either strength was observed, nor did the different degrees of dilution appear to affect the results as regards the maggots.

Little protection from maggots was found as the result of this treatment. The material for 1 acre would cost about $10, and the cost of labor, making and applying it would be about $12 or $14 more. The total cost for three applications to an acre of onions would therefore be $60 or more, and would make this treatment too expensive, even if it were effective.

Carbolic Acid Emulsion. — This was prepared as follows: soap 1 pound, water 1 gallon, crude carbolic acid 1 pint; dissolve the soap in water (boiling, to hasten solution); add the carbolic acid and churn as for kerosene emulsion until a creamy substance thoroughly emulsified has been produced.

This was diluted to three strengths: 1 part to 30, 1 to 40 and 1 to 50 parts of water. It was applied in the same way as the soap wash and the application repeated every other week.

The results obtained so far as control of maggots is concerned were the most satisfactory of any, decidedly checking the infestation in the rows to which it was applied. On small areas it would appear to be the most effective of the materials tested, and its application to large fields would be determined largely by its cost. This, for materials and labor together, was calculated at from $8 to $12 per acre, according to the strength used. It would probably need to be applied at least three, and probably four times, however, to be effective, which would make the total cost from $35 to $50. It should also be borne in mind that it was not an entire success, but only relatively so. So far as could be determined the three strengths were about equally effective.

General Conclusions.

None of the materials tested proved satisfactory, though the carbolic acid emulsion gave the best results. It was also one of the less expensive treatments, costing from about $8 to $12 per acre for each application. It is not improbable that some of the other materials, applied frequently and with care, might prove of some value, but only on small areas would this be possible at a reasonable expense.

The whole experiment indicates: (*a*) that no entirely effective method of controlling the onion maggot has as yet been discovered; (*b*) that many of those thus far recommended are of little value, at least on large fields; (*c*) that the cost of treatment with most of them is so great as to render them unavailable for large areas. Finally, the most promising line of investigation seems to be the discovery of something which will effectually repel the insects or destroy the maggots, and which can be applied either as a part of the planting process or in connection with cultivation, thus avoiding the necessity of special treatments by combining these with usual methods of cultivation. Experiments along these lines are now being planned.

THE INHERITANCE OF BLOSSOM COLOR IN BEANS.

J. K. SHAW.

For several years we have given considerable time to the study of heredity in beans. Nineteen varieties have been used, and the method uniformly followed has been to make a cross of two differing types and self-fertilize the progeny through four generations, keeping careful records of the characters under observation as they appeared.

The self-fertilization has been done by covering the plants with muslin bags, each supported by a short stick or bent wire. Some have been grown in the greenhouse during the winter, and these have of course required no protection. Some of the crossing has been done in the greenhouse and some in the field, in which case paper bags have been used for protection from insect interference. The parent plants have each received a number, and our records show just what plants were involved in any particular cross. The system of records used has already been described by the writer.[1] In this way a vast amount of data has been accumulated and many interesting questions are presented for study. It is the purpose of this paper to deal with the inheritance of blossom color, leaving the other characters studied for later consideration.

In the early part of the work the plants used were from commercial seed bought in the open market. When the writer took charge of the work the policy was adopted of securing pure races as quickly as possible by self-fertilizing individual plants, and since then these have been used in the crossing work. It is probable that some of the plants used first, while externally typical of the variety, were not gametically pure and led to confusing results.

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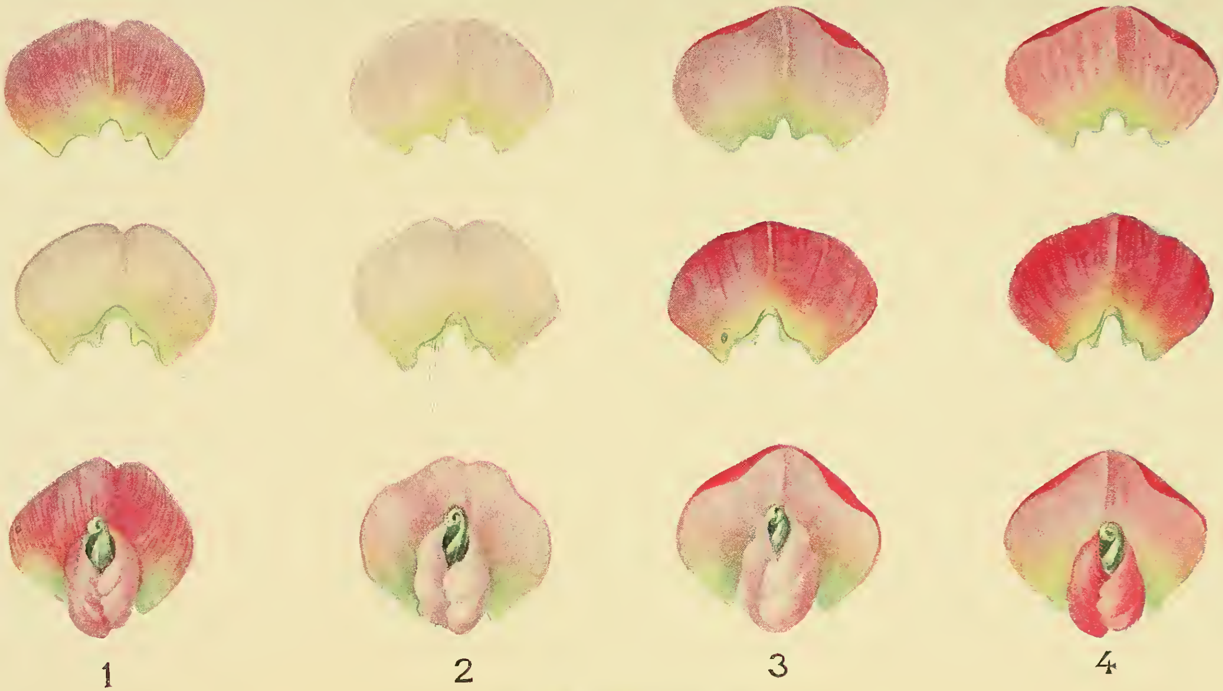
[1] American Naturalist, Vol. XLV., p. 701 (1911).



Flower Colors of Beans.

Fig. 1. Pink. Fig. 2. Light pink. Fig. 3. "Waxy pink." Fig. 4. Crimson. The upper figure in each case represents the inside and the middle figure the outside of the banner petal.

As indicated by external appearance the blossom colors of the varieties under experiment fall under four types. These have been designated as white, light pink, pink and crimson. In addition to these parental colors a new form has appeared, and this has been called "waxy pink" for want of a better term. All the colored types are somewhat variable, and some difficulty has been occasionally experienced, especially in the early stages of the work, in separating them; but it is believed that this has not been serious enough to affect the results. The blossom color of the varieties used is as follows: —

White: —
Creaseback.[1]
Davis Wax.
Golden-eyed Wax.
Keeney Rustless.
Red Valentine.
Wardwell.
White Marrow.
Light pink: —
Burpee Stringless.
Golden Carmine.
Giant Stringless.
Mohawk.
Warren.
Warwick.
Pink: —
Challenge Black Wax.
Currie.
German Black Wax.
Prolific Black Wax.
Crimson: —
Blue Pod Butter.

Inasmuch as the blossom color and the pigmentation of the seed-coat seem to be correlated, it may be well to state here the seed-coat colors of these varieties, as follows: —

Blue Pod Butter, buff.
Burpee Stringless, coffee brown.
Challenge Black Wax, black.
Creaseback, white.
Currie, black.
Davis Wax, white.
German Black Wax, black.
Giant Stringless, yellow.
Golden Carmine, mottled, buff and reddish.
Golden-eyed Wax, white; small yellow eye.
Keeney rustless, white; large dark-reddish mottled eye.
Mohawk, mottled, reddish brown.
Prolific Black Wax, black.

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[1] In nomenclature we follow Jarvis, Cornell Exp. Sta. Bull. No. 260. Any one desiring a complete description of these varieties is referred to this bulletin or Bu. Plant Ind. Bull. No. 109.

Red Valentine, reddish mottled.
Wardwell, white; large dark-brownish eye.
Warren, deep red.
Warwick, deep reddish mottled.
White Marrow, white.

The blossoms of the varieties classified as white-flowered have been invariably a pure white so far as observed, with the exception of Red Valentine. This sort has occasionally shown flowers with a very slight pinkish tinge on the more exposed positions of the keel; while drying with age they take on a distinct waxy tinge. It should be noted that the seeds of this variety have mottled seed-coats while all the other white-flowered varieties are either white seeded or eyed.

The varieties classified as light pink have flowers with a distinct tinge of pink, especially on the keel. They do not show the waxy color of white-flowered sorts while drying, and are readily separated from them even though this pink tinge may be very slight. From the pink-flowered sorts, on the other hand, they are not so easily distinguished, and it is evident that a few errors have here been recorded, but care has been taken not to allow these to lead to any false conclusions.

The pink-flowered varieties have a deep shade of pink over the entire flower, including the inside of the banner petal, but the outside is white. The so-called crimson flowers of the Blue Pod Butter are more properly a purplish crimson, and invariably the leaves and stems of the plants are deeply tinged with dark purple. These flowers are distinguished from the pink ones, not only by their darker shade but more certainly by the outside of the banner petal which is purplish crimson instead of uncolored.

The waxy pink flowers have appeared only in crosses having Blue Pod Butter as one of their parents. They resemble the light pink blossoms but are readily distinguished from them. The pigment seems deepest on the outside of the banner, and the whole plant invariably has a peculiar waxy-brownish-yellow appearance.

These colors are well represented in the colored plate.

Turning now to a discussion of the tabulated data, Table 1 shows the results of crossing varieties with light pink flowers with white-flowered sorts, where only light pink and white-flowered plants resulted. Some such crosses gave pink-flowered plants, and these are given in Table 2. The results shown are generally in accordance with Mendelian expectation, assuming the light pink blossom to be dominant over white. There are two cases where a white-flowered parent has colored offspring. It is possible that in the cross Red Valentine and Giant Stringless this is due to error in observation of the color of the flowers of the parent plant on account of the effect of bagging to insure self-fertilization, this having a tendency in some cases to check color development. The same may be said regarding the similar case in Red Valentine × Mohawk. The case of the single light pink plant in Golden-eyed Wax × Giant Stringless is unexplained. Some departures from the numerical expectation are recorded. A marked excess of white-flowered plants occurs in the crosses involving Golden-eyed Wax, and a similar excess is shown in later tables when this variety is involved.

TABLE 1.—*Light Pink and White.*

	F₁.	F₂.			F₃ AND F₄.					
					WHITE PARENTS.			LIGHT PINK PARENTS.		
		White.	Light Pink.	Total.	White.	Light Pink.	Total.	White.	Light Pink.	Total.
Burpee Stringless × Red Valentine,	Light pink,	8	40	48	-	-	-	0 32	8 67	8 99
Red Valentine × Burpee Stringless,	Light pink,	22	71	93	25	0	25	0 47	107 90	107 137
Burpee Stringless × Wardwell,	Light pink,	9	19	28	6	0	6	3	14	17
Burpee Stringless × White Marrow,	Light pink,	17	67	84	58	0	58	0 96	54 246	54 342
White Marrow × Burpee Stringless,	Light pink,	15	47	62	41	0	41	0 59	205 194	205 253
Giant Stringless × Golden-eyed Wax,	Light pink,	61	88	149	10	0	10	-	-	-
Golden-eyed Wax × Giant Stringless,	Light pink,	26	34	60	16	1	17	0 10	17 21	17 31
Giant Stringless × Red Valentine,	Light pink,	5	34	39	18	0	18	0 2	31 3	31 5
Red Valentine × Giant Stringless,	Light pink,	16	25	41	17 33	18 0	35 33	-	-	-
Giant Stringless × Wardwell,	Light pink,	24	53	77	84	0	84	0 25	14 88	14 113
Mohawk × Red Valentine,	Light pink,	9	22	31	-	-	-	-	-	-
Red Valentine × Mohawk,	Light pink,	17	27	44	89 6 0	0 6 23	89 12 23	0 20	15 51	15 71

In Table 2 are given results from certain crosses that are not in accordance with expectation, in that deeper colored flowers appear among the offspring than those possessed by either parent variety. In the cross of Golden-eyed Wax × Burpee Stringless there appear two pink and one crimson flower in the F_3 generation. These all occur among the progeny of a single selfed plant having light pink flowers. The pink-flowered plants bore black beans, while the crimson-flowered plant bore dark mottled beans. The significance of this correlation will be discussed a little later. In the crosses of Burpee Stringless and Giant Stringless with Keeney Rustless, pink flowers occur in both the F_2 and later generations, and in such numbers as to preclude the possibility of errors in observation. Coincident with these pink flowers occur black or dark mottled seeds, and coincident with the white flowers appear eyed beans, a character coming from the eyed parent, Keeney Rustless. The cross of White Marrow × Golden Carmine presents a variety of surprises hard to comprehend. As will be shown later, this is common with the White Marrow. It is most undependable in its behavior in crosses. It is evident that some of this is due to a mixture of strains which may be alike in external appearance but behave differently in crossing, but there are other abnormalities shown that will bear much investigation. The reciprocal crosses of Warwick and Creaseback show pink flowers, again coincident with black pigment in the seed coat. It is evident that Creaseback carries a factor that blackens any pigment it may encounter, at least so far as our experience goes, and this blackening is accompanied by pink flowers. None of the pink-flowered plants have bred true to flower color. All seem to be heterozygous.

TABLE 2. — *Light Pink and White.*

	F₁	F₂.				F₃ AND F₄.								
						WHITE PARENT.	LIGHT PINK PARENTS.				PINK PARENTS.			
		White.	Light Pink.	Pink.	Total.	White.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.
Golden-eyed Wax × Burpee Stringless, .	Light pink, .	9	25	0	32	31	0	21	0	21	–	–	–	–
							19	63	0	82				
							16	64	2	83[1]				
Keeney Rustless × Burpee Stringless, .	Light pink, .	3	8	6	17	4	2	0	22	24	6	8	13	27
							4	11	0	15				
Giant Stringless × Keeney Rustless, .	Light pink, .	5	5	10	20	–	3	4	11	18	6	0	27	33
							1	8	0	9	1	15	0	16
White Marrow × Golden Carmine, . .	–	6	2	7	15	42	0	15	0	15	1	0	5	6
							0	12	0	13[1]	0	18	45	64[1]
							0	1	0	6[2]	0	0	6	12[3]
							0	6	1	7	0	2	0	2
Warwick × Creaseback, ...	Pink, . .	9	13	66	88	–	–	–	–	–	–	–	–	–
Creaseback × Warwick, ...	Pink, . .	4	3	15	22	59	0	76	0	76	–	–	–	–
							40	120	0	160				

[1] Also 1 crimson, see text.

[2] Also 5 "waxy pink."

[3] Also 6 crimson.

In Tables 3 and 4 are given our results of crossing pink with white-flowered varieties, the division into two tables being simply for convenience in arrangement. A striking thing shown in this table is the excess of white-flowered plants in the crosses involving Golden-eyed Wax. This occurs in all cases except in the F_2 generation of the cross with Prolific Black Wax. It is seen also in crosses with light pink-flowered sorts, especially with Giant Stringless in Table 1, also in crosses with Blue Pod Butter in Table 5. The total number of hybrid plants from crosses of Golden-eyed Wax with pigmented flowered variations is 1,053, of which 407 are white-flowered, while the expectation of one-fourth of the total number is 262. This is a proportion of 1.59:1 instead of 3:1. This departure from expectation is probably due to a correlation between blossom color and seed-coat colors or color patterns. Another thing that calls for explanation is the occurrence of light pink flowers in the second generations in Table 4. These appear in a majority of the crosses but not in all of them. There can be little reason to doubt that nearly all, at least, of these classifications of blossom color are correct, for our policy has been not to record a departure from expectation in any case of doubt, but only where the unexpected character is reasonably typical. As previously explained, these two color types are quite distinct. It may be observed that White Marrow gives peculiar results here as in crosses already discussed. It is probable that the appearance of the light pink blossoms in these crosses is connected with the pigmentation of the seed-coat, and may be explained by a study of the seed-coat color. White Marrow evidently carries several factors modifying pigmentation both of seed-coat and blossom.

TABLE 3. — *Pink and White.*

	F_1.	F_2.				F_3 AND F_4.				
						WHITE PARENTS.		PINK PARENTS.		
		White.	Light Pink.	Pink.	Total.	White.	Pink.	White.	Pink.	Total.
Challenge Black Wax × Davis Wax,	Pink,	84	5	245	334	-	-	0 8	11 19	11 27
Challenge Black Wax × Golden-eyed Wax,	Pink,	73	14	107	194	69	0	0 9	56 16	56 25
Challenge Black Wax × Creaseback,	Pink,	82	4	367	453	-	-	0 9	19 33	19 42
Golden-eyed Wax × Currie,	Pink,	99	10	140	249	55	0	0 39	34 33	34 79[1]
Currie × Red Valentine,	Pink,	43	26	71	140	65	0	0 13	114 11	114 24
Red Valentine × Currie,	-	103	7	292	402	185	0	0 33	143 100	143 133
Currie × White Marrow,	-	38	0	67	105	225	0	0 48	30 135	30 231[2]
Golden-eyed Wax × Prolific Black Wax,	-	19	0	28	47	94	0	0 10	4 21	4 31
Creaseback × Prolific Black Wax,	Pink,	15	0	25	40	-	-	-	-	-

[1] Also 6 light pink and 1 crimson.

[2] Also 8 light pink.

TABLE 4. — *Pink and White.*

	F_1.	F_2.				F_3 AND F_4.											
						WHITE PARENTS.				LIGHT PINK PARENTS.				PINK PARENTS.			
		White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.
White Marrow × German Black Wax,	Pink, .	27	27	44	98	31	0	0	31	4	13	0	17	0	7	5	12
										0	2	9	11	9	11	10	30
						54	13	0	67	23	1	0	24	0	0	34	34
Prolific Black Wax × Red Valentine,	-	13	12	21	46	2	0	5	7	14	0	10	24	17	0	55	72
						158	0	0	158	5	2	6	13	25	7	45	77
Red Valentine × Prolific Black Wax,	Pink, .	60	170	42	272	128	0	0	128	2	0	3	5	0	0	42	42
		9	0	18	27					0	3	6	9	7	0	25	32
										0	0	28	28	0	1	5	6
														11	8	34	53
White Marrow × Prolific Black Wax,		2	0	10	12	60	0	0	60	1	1	1	3	24	0	82	106

In Table 5 are shown the results of crossing various white-flowered varieties with Blue Pod Butter, the one crimson-flowered variety under observation. The results of these crosses present several unexpected complications. The most striking is the new and distinct blossom color designated as "waxy pink." This resembles the light pink more than any of the other colors, the amount of coloration being about the same, but its distribution is different, being heaviest on the outer part of the banner petal. It carries no suggestion of purple, and the entire plant has a waxy-yellow tinge distinct from the deeper green of the other plants. It will be noted that this type appears in all crosses of Blue Pod Butter, given in Table 5, except those with Davis Wax and Creaseback. It also appears in all crosses of Blue Pod Butter with varieties having light pink flowers shown in Table 7, but appears in none of the crosses with pink-flowered black-seeded varieties given in Table 8. It must be regarded as resulting from a cross of Blue Pod Butter with some, but not all, white or light pink-flowered varieties.

TABLE 5. — *Crimson and White.*

	F_1.	F_2.						F_3 AND F_4.											
								WHITE PARENTS.						LIGHT PINK PARENTS.					
		White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.
Blue Pod Butter × Davis Wax, .	Crimson, .	7	0	9	11	0	27	-	-	-	-	-	-	-	-	-	-	-	-
Davis Wax × Blue Pod Butter, .	Crimson, .	17	0	11	41	0	69	-	-	-	-	-	-	-	-	-	-	-	-
Blue Pod Butter × Golden-eyed Wax,	4 crimson, 1 pink.	17	3	7	21	7	55	-	-	-	-	-	-	-	-	-	-	-	-
Golden-eyed Wax × Blue Pod Butter,	Crimson, .	24	0	5	23	8	60	5 6	0 0	0 0	0 1	0 1	5 8	-	-	-	-	-	-
Blue Pod Butter × Red Valentine, .	Pink, .	8	3	5	31	2	49	-	-	-	-	-	-	-	-	-	-	-	-
Blue Pod Butter × Wardwell, . .	Pink, . .	12	3	6	16	3	40	5	0	1	0	0	6	3	4	0	0	4	11
Wardwell × Blue Pod Butter, . .	Pink, . .	14	7	11	18	5	55	8	0	0	0	0	8	-	-	-	-	-	-
Blue Pod Butter × Creaseback, .	Crimson, .	74	2	28	137	0	241	-	-	-	-	-	-	-	-	-	-	-	-
Creaseback × Blue Pod Butter, .	Crimson, .	37	1	9	77	0	124	-	-	-	-	-	-	-	-	-	-	-	-
Blue Pod Butter × White Marrow, .	30 crimson, 5 pink.	26 13 14	0 14 6	1 17 7	27 35 25	4 6 7	58 81 59	254 12 31	0 0 2	0 10 0	0 0 0	0 0 26	254 22 59	3 0 0	0 0 2	10 8 1	0 0 1	0 0 5	13 8 9
White Marrow × Blue Pod Butter, .	Crimson, .	3 12	4 4	6 5	4 23	0 7	17 51	5	0	0	0	0	5	3	1	0	0	0	4

TABLE 5. — *Crimson and White* — Concluded.

	F_3 AND F_4 — *Con.*																	
	PINK PARENTS.						CRIMSON PARENTS.						WAXY PINK PARENTS.					
	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	White.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.
Blue Pod Butter × Davis Wax,	0 3	0 0	17 16	0 0	0 0	17 19	0 3	0 0	0 1	5 2	0 0	5 6	-	-	-	-	-	-
Davis Wax × Blue Pod Butter,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blue Pod Butter × Golden-eyed Wax,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Golden-eyed Wax × Blue Pod Butter,	2 5	1 0	6 14	1 0	0 0	10 19	0 4 5	0 0 0	0 1 2	6 3 3	0 0 1	6 8 11	4	0	0	0	7	11
Blue Pod Butter × Red Valentine,	-	-	-	-	-	-	0	1	1	8	1	11	-	-	-	-	-	-
Blue Pod Butter × Wardwell,	-	-	-	-	-	-	0 0 0	0 0 1	6 4 1	11 4 11	0 2 3	17 10 16	-	-	-	-	-	-
Wardwell × Blue Pod Butter,	3	1	8	0	0	12	4 5	0 1	2 7	4 14	0 1	10 28	0	3	0	0	3	6
Blue Pod Butter × Creaseback,	0 6 3	0 1 0	10 27 7	0 0 2	0 0 0	10 34 12	0 6 23	0 0 0	4 0 12	13 44 59	0 0 0	17 50 94	-	-	-	-	-	-
Creaseback × Blue Pod Butter,	-	-	-	-	-	-	7 2	0 0	0 4	23 5	0 0	30 11	-	-	-	-	-	-
Blue Pod Butter × White Marrow,	0 0 2 49	0 0 1 0	10 2 6 117	0 0 0 0	0 21 0 0	10 23 9 166	0 0 0 4 12 0 0 7 4	0 0 3 0 0 0 0 0 1	0 3 4 0 9 0 4 0 5	8 17 5 13 30 8 4 6 12	0 0 0 0 0 2 1 2 0	8 20 12 17 51 10 9 15 22	7 2	0 0	0 0	0 1	15 1	22 4
White Marrow × Blue Pod Butter,	0	2	5	0	0	7	0	0	0	3	4	7	0	1	0	0	4	5

In the third and fourth generations from the cross it appears commonly among the progeny of light pink and crimson parents, and in two cases from white-flowered parent plants, and in one case from a pink-flowered parent. It is probable that these three cases should be regarded as exceptional, and it is possible that one or two may arise from erroneous observations. When self-fertilized it commonly breeds true, or it may yield light pink or white progeny. In one case it yields one crimson-flowered plant. There have been several cases where such plants have appeared most unexpectedly from parent plants of lighter-colored flowers, a thing that we are unable to explain unless they be regarded as mutants.

Light pink flowers appear in all crosses of Table 5, except the one with Davis, and pink flowers in all of them.

A study of the ratios of these several blossom colors leads only to confusion. It is probable that the theoretical ratios differ in the different crosses, and, as in many other cases, are correlated with the seed-coat pigmentation.

Table 6 gives the results of crossing pink and light pink-flowered varieties. Only the parent types appear, as a rule; the pink is uniformly dominant, and the proportions, while departing considerably in some cases from the expected ratio of 3:1, are perhaps not further than might be expected.

TABLE 6. — *Pink and Light Pink.*

	F₁.	F₂.			F₃ AND F₄.					
					LIGHT PINK PARENTS.			PINK PARENTS.		
		Light Pink.	Pink.	Total.	Light Pink.	Pink.	Total.	Light Pink.	Pink.	Total.
Burpee Stringless × German Black Wax,	Pink,	17	79	96	131	0	131	0	104	104
					2	2	4	19	61	80
German Black Wax × Burpee Stringless,	Pink,	25	48	73	20	0	20	0	111	111
					36	68	104	37	56	93
Burpee Stringless × Prolific Black Wax,	Pink,	16	8	24	8	0	8	0	6	6
					2	1	3	2	11	13
Warwick × Challenge Black Wax,	Pink,	10	6	16	257	0	257	0	100	100
								7	34	41
Challenge Black Wax × Warwick,	Pink,	9	20	29	-	-	-	-	-	-
Currie × Mohawk,	Pink,	97	202	300[1]	199	0	199[2]	0	56	56
								8	19	27
Mohawk × Currie,	Pink,	16	22	38	-	-	-	-	-	-
Prolific Black Wax × Mohawk,	-	0	3	3	-	-	-	14	45	59

[1] Also 1 white flower.

[2] One light pink parent gave 21 white, see text.

There are, however, a few irregularities. One is the appearance in F_3 and F_4 of pink-flowered plants from light pink parents, and another is the appearance of white-flowered plants in the cross of Currie × Mohawk. The single white-flowered plant in F_2 was covered with a muslin bag for self-fertilizing which may have suppressed the color, but the 21 whites from a light pink parent cannot be thus accounted for; they bred true in the succeeding generations so far as flower color was concerned.

TABLE 7. — *Crimson and Light Pink.*

	F_1.	F_2.					F_3 AND F_4.																	
							LIGHT PINK PARENTS.					PINK PARENTS.					CRIMSON PARENTS.					WAXY PINK PARENTS.		
		Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Pink.	Crimson.	Waxy Pink.	Total.	Light Pink.	Waxy Pink.	Total.
Blue Pod Butter × Burpee Stringless,	Crimson,	33 16	23 34	78 64	3 1	137 115	120 0 71	0 0 0	0 0 0	0 41 55	120 41 127[1]	0 15	7 28	0 0	0 0	7 43	0 0 0 1 0 3	0 19 8 0 0 4	139 33 43 16 11 9	0 0 1 4 1 1	139 52 52 21 12 17	0	44	44
Burpee Stringless × Blue Pod Butter,	Crimson,	17 6	24 20	60 46	0 5	101 77	2 32	0 0	0 0	0 12	2 44	0 9	27 36	0 0	0 0	27 45	0	0	18	0	18	-	-	-
Blue Pod Butter × Giant Stringless,	Crimson,	6	2	8	1	17	5	0	0	6	11	2	17	0	0	19	1	2	9	0	12	-	-	-
Giant Stringless × Blue Pod Butter,	Crimson,	8	15	35	11	69	-	-	-	-	-	2	0	0	0	2	0	1	7	0	8	-	-	-
Blue Pod Butter × Mohawk,	Crimson,	3	1	3	2	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mohawk × Blue Pod Butter,	Crimson,	1	3	9	1	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blue Pod Butter × Warwick,	Crimson,	7	12	23	9	51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warwick × Blue Pod Butter,	Crimson,	28	33	87	21	169	32	0	0	0	32	0 25	5 30	0 0	0 0	5 55	0 1	0 1	30 2	14 2	44 6	0 3	51 16	51 19
Low Champion × Blue Pod Butter,	Crimson,	7	11	38	6	62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Also 1 white.

The crosses of Blue Pod Butter, the crimson-flowered varieties given in Table 7, have been already discussed in connection with Table 5. Only one white-flowered plant appeared among those crosses, and that was in the F_3 generation of Blue Pod Butter × Burpee Stringless. No reason for its appearance can be assigned.

Table 8 gives the results of crossing Blue Pod Butter with pink-flowered black-seeded sorts. As already stated none of the waxy-pink flowers appear among these crosses. White flowers appear among the progeny of the crosses of Blue Pod Butter × German Black Wax, but not in the reciprocal cross, also in the cross of Currie and Blue Pod Butter. Light pink flowers appear rarely, and they may be extreme variants of pink flowers in which the color has been partially suppressed by environmental conditions.

TABLE 8. — *Crimson and Pink.*

	F₁.	F₂.					F₃ and F₄.									
							PINK PARENTS.					CRIMSON PARENTS.				
		White.	Light Pink.	Pink.	Crimson.	Total.	White.	Light Pink.	Pink.	Crimson.	Total.	White.	Light Pink.	Pink.	Crimson.	Total.
Blue Pod Butter × Challenge Black Wax, .	Crimson,	0	2	20	56	78	-	-	-	-	-	-	-	-	-	-
Challenge Black Wax × Blue Pod Butter, .	Crimson,	0	0	67	170	237	0 0	0 1	59 1	0 7	59 9	0 0 0	0 0 1	0 4 3	17 15 15	17 19 19
Blue Pod Butter × Currie, ...	Crimson,	0	0	8	48	56	-	-	-	-	-	-	-	-	-	-
Currie × Blue Pod Butter, ...	Crimson,	0	4	89	156	249	0 2 5	0 0 4	35 3 18	0 0 0	35 5 27	0 0 2	0 0 9	0 7 3	14 43 9	14 50 23
Blue Pod Butter × German Black Wax, .	Crimson,	10 0	0 0	12 9	31 25	53 34	0 7	0 0	10 20	0 0	10 27	0 6 2	0 0 1	0 4 2	13 13 9	13 23 14
German Black Wax × Blue Pod Butter, .	Crimson,	0	0	17	59	76	0 0 0	0 1 0	6 19 6	0 0 22	6 20 28	0	0	14	25	39
Blue Pod Butter × Prolific Black Wax, .	Crimson,	0	0	56	141	197	0	0	108	0	108	0 0	0 0	0 10	38 10	38 20
Prolific Black Wax × Blue Pod Butter, .	Crimson,	0	0	32	112	144	0	0	27	0	27	0	0	0	25	25

It is the usual expectation that when two white-flowered varieties are crossed only white flowers should result. Table 9 shows that in beans this is by no means true. It comprises all such crosses save one, Wardwell × Golden-eyed Wax, which has been bred for three generations from the cross, yielding about 100 plants, with none but white flowers appearing. All the rest of such crosses have yielded colored flowers in each generation bred. All these crosses involve varieties one or both of which bear pigmented seeds, these adding further evidence that blossom color is governed largely by the pigmentation of the seed coat.

TABLE 9. — *White and White.*

	F₁.	F₂.				F₃ AND F₄.											
						WHITE PARENTS.				LIGHT PINK PARENTS.				PINK PARENTS.			
		White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.	White.	Light Pink.	Pink.	Total.
Red Valentine × Golden-eyed Wax,	-	16 175 8	16 0 28	0 0 2	32 175 38	169 1	0 3	0 10	169 14	0 0 3 3	4 0 12 0	0 6 0 8	4 6 15 11	0 1 4	0 1 0	38 14 21	38 16 25
Golden-eyed Wax × Red Valentine,	White,	61	5	0	66	-	-	-	-	-	-	-	-	-	-	-	-
Red Valentine × Keeney Rustless,	Pink,	6 12	11 0	0 24	17 36	33	0	0	33	16	0	23	39	0 10	0 0	5 33	5 43
Red Valentine × White Marrow,	2 light pink, 2 pink.	47 19 28	0 36 29	0 0 1	47 55 58	165 20	0 16	0 0	165 36	0 10	33 13	0 0	33 23	-	-	-	-
White Marrow × Red Valentine,	-	6	11	0	17	65	0	0	65	7	0	12	19	0	0	57	57
Golden-eyed Wax × Creaseback,	-	15	0	13	28	5	0	0	5	-	-	-	-	69	0	65	134
Golden-eyed Wax × White Marrow,	-	40 34	56 2	0 0	96 36	9	0	0	9	10	38	0	48	-	-	-	-
White Marrow × Golden-eyed Wax,	-	12	11	0	23	15 41	0 22	0 0	15 63	-	-	-	-	-	-	-	-
Wardwell × Keeney Rustless,	Light pink,	16	0	0	16	88 10	0 0	0 3	88 13	-	-	-	-	-	-	-	-
White Marrow × Keeney Rustless,	-	15	8	0	23	30	0	0	30	26	17	0	43	-	-	-	-
Wardwell × White Marrow,	Light pink,	12 13	9 1	0 16	21 30	38	0	0	38	-	-	-	-	12	3	16	31
Davis Wax × Keeney Rustless,	Pink,	6	0	15	21	-	-	-	-	-	-	-	-	-	-	-	-

The following crosses of two light pink flowered varieties gave only light pink flowered plants in the progeny.

Golden Carmine × Mohawk.
Mohawk × Golden Carmine.
Burpee Stringless × Giant Stringless.
Mohawk × Burpee Stringless.
Giant Stringless × Mohawk.
Mohawk × Giant Stringless.

One cross of Warren × Burpee Stringless gave, in F_2, 6 light pink, 3 pink, 13 crimson and 2 waxy pink, the F_1 plants being light pink. It should be said that while both of these varieties are classed as light pink they are not identical in the appearance of the blossom color. Only one cross of pink-flowered varieties has been made, — Challenge Black Wax × Prolific Black Wax. All the resulting plants have borne only pink flowers.

In this paper we have attempted little more than setting forth some of the facts concerning the inheritance of blossom color that have appeared in the work of the past five years. Beyond doubt the interpretation of these results is to be made through an analysis of the records of the inheritance of seed-coat color. It is hoped that this work may be accomplished, including another season's observation, in time for presentation in the next annual report of the experiment station.

DEPARTMENT OF VETERINARY SCIENCE.

REPORT OF THE VETERINARIAN.

JAS. B. PAIGE, D.V.S.

During the past year the policies of former years in dealing with the work in this department have been adhered to. The personnel of the department is the same as last year. With the addition of Dr. G. E. Gage to the working force it has seemed possible to devote more time to investigation problems than in former years, when one man had to attend to the entire work of the department of both college and experiment station. Owing to the demands of a larger number of students in some of the classes, and an increase in the amount of instruction given, it has been found that much of the time of an additional assistant has been utilized, not for investigational work as had been expected, but for teaching.

If the veterinary department of the experiment station is to render such service to the stock owners of the State as they are justly entitled to, it is imperative that a competent pathologist, who shall devote practically all his time to investigational problems, be added to the staff of the department at the earliest possible date.

There are numerous important problems that call for immediate and thorough study. Some of these studies promise the most flattering results from a practical and economic standpoint in the prevention, cure or eradication of animal diseases.

During the year there has been the usual amount of correspondence with farmers from all parts of the State relative to the existence and treatment of disease of farm animals. This correspondence is fruitful of the best results in many instances. It is often possible, from the information received from a stock owner by letter, to diagnose the disease of his animal and to advise a line of treatment that will lead to a cure of it. At other times, additional information may be requested or a specimen asked for, which, received and examined, enables us to arrive at a correct diagnosis upon which a successful course of treatment for the individual animal or for an entire herd is based.

The diagnosis work that is carried on each year is gradually increasing. It is closely correlated with the correspondence mentioned above. Frequently specimens are sent by farmers direct to the department, with a request that an examination be made, and a report as to the nature of the disease, its cause, prevention or cure returned. At times material from sick or dead animals is sent upon request of the department when a positive diagnosis cannot be made from information obtained by letter from the owner of the animal. Since Jan. 1, 1912, approximately 100 specimens have been received, examined and information returned to the senders of them with advice as to course of treatment to be followed in dealing with the several diseases. This diagnosis work is not only beneficial to the farmers, enabling them in many instances to avail themselves of the services of the station veterinarian, but it is of value to the department, as it provides a means by which we are kept in touch with the various ailments of farm animals throughout the State. In addition, the material received from different sections of the State furnishes, at times, valuable material for demonstrations with the students taking the courses in veterinary science and pathology.

It frequently happens that valuable material for study is received from stock owners. Through specimens that have been received we have on several occasions been able to diagnose the existence of animal diseases in Massachusetts that were not supposed to exist here, and also we have found disease not previously described. As good examples of these may be mentioned verminous bronchitis of sheep and a peculiar paralytic disease of fowls.

Among some of the more interesting specimens that have come to the department during the year may be mentioned verminous bronchitis of sheep; necrotic stomatitis of calf; traumatic pericarditis of steer; purulent endometritis and uterine torsion of cow; cholera and demodectic scabies of the pig; traumatic peritonitis, due to perforation of gizzard of fowl with wire nail; variola; fatty infiltration of liver of fowl; and bacillary white diarrhœa of chicks. Several samples of milk, contaminated with special species of bacteria causing such abnormal conditions as "curdled," "bitter" and "gassy" milk, have been received and examined, and advice given as to how the trouble could best be eliminated and prevented.

Whenever the seriousness and nature of an outbreak of disease seems to warrant it a visit is made to the farm where the trouble makes its appearance, for the purpose of making a critical study of conditions under which the disease of the animals has developed and exists. In such cases, in order not to encroach upon the field and practice of the local veterinarian, provided there is one in the locality, the visit is usually made in company with the local practitioner.

Another field in which the department has been able to render some service to the stockmen of the State has been in the examination of stables and advising with reference to the improvement of sanitary conditions. This has not only been done with stables already constructed, but also, in some instances, plans of proposed stables have been submitted for examination and suggestions.

As already mentioned, the department has not been able to carry on as much original investigation as it desired on account of the amount of teaching that it has been necessary to do. This has been due, in part, to the fact that we have taught throughout the year the courses in bacteriology that eventually will be taken over into the new department of microbiology, created by trustee vote last year, and to which Dr. C. E. Marshall was elected the head. When we are relieved of this line of teaching it is hoped that more time can be given to investigation problems. It will not, however, completely remedy the difficulty, as courses in pathology will be introduced into the curriculum that will be carried by this department. While these will not be as time-consuming as the work in bacteriology, they will interfere sufficiently with the class of investigational work that is demanded to warrant the employment of a pathologist on the experiment station staff who shall be able to devote practically his entire time to the study of pathological problems that are pressing for solution.

As mentioned in the report of last year, there is an unusual amount of hog cholera in the State as compared with former years. It is assuming alarming proportions, more especially in herds fed upon "city" swill or garbage. Its cause in these herds is to be attributed to an infection following the ingestion of uncooked pork scrap, from sources where cholera exists, that finds its way into the swill barrel of the hotel, boarding house or private house, and finally to the trough of the hogs. Once an animal of the herd becomes affected it spreads contagion rapidly to healthy animals with which it is kept.

The department, in co-operation with Mr. Fred F. Walker, Commissioner of the Department of Animal Industry, under whose jurisdiction all contagious animal diseases come, has undertaken some investigations to determine more accurate methods for the diagnosis of cholera in the hog, and its cure and control by the use of anti-hog cholera serum.

In December last, in company with Mr. Walker, I attended the meeting of the State live stock sanitary boards at Chicago, where means and methods for the preparation of serum and the control of the disease were fully discussed by the highest authorities in the country. Since then serum has been used upon several lots of hogs, in which cholera was known to exist, to determine its value as a curative and preventive agent. The herds are located in the middle part of the State so as to permit of occasional inspection without the sacrifice of too much time.

While the work upon hog cholera has not progressed sufficiently to warrant a full report at this time, I feel justified in predicting that by the use of properly prepared serum, under certain conditions, we shall be able to greatly lessen the annual loss to the swine owners from this disease, and in the end succeed in protecting against its ravages to the extent that it may be made one of the most profitable branches of animal industry in the Commonwealth.

Already steps have been taken to prepare, in an experimental way, small quantities of anti-hog cholera serum in the department. If the results of the experiment seem to warrant it, it is possible that in the near future the experiment station may be justified in preparing the serum on a sufficiently large scale to enable it to be distributed at a slight cost, sufficient to pay the actual cost of production, to the hog owners of the State. Should this be done it would be necessary to co-operate with the Department of Animal Industry.

Some years ago, working with the Chief of the Cattle Bureau, of the State Board of Agriculture, the department organized the work for the prevention of black leg in cattle by the use of vaccine, obtained from the Bureau of Animal Industry of the Federal Department of Agriculture. The supervision of the work is still in the veterinary department, in a general way, but no time is given to the actual vaccination of animals about the State, this being done by the special agent of the present Department of Animal Industry.

Although Dr. George E. Gage, assistant professor of animal pathology of the veterinary department, receives no compensation from the experiment station, he has devoted as much time as his teaching duties would permit to the investigation of several important avian diseases, among which is one that appears, from the work already done, never to have been described before. The study of this obscure and interesting disease is being carried along as rapidly as possible under existing conditions, and it is hoped that at a later date the details of the investigation will be brought out in bulletin form.

REPORT OF CRANBERRY SUBSTATION FOR 1912.

H. J. FRANKLIN.

The experiments conducted and observations made during the year may be discussed under the eight following heads: weather observations, frost protection, fungous diseases, varieties, blossom pollination, fertilizers, insects and miscellaneous.

1. Weather Observations.

The season's observations began late in April, the Weather Bureau having at this time installed the following instruments at the station bog: elevated instrument shelter, thermograph, barograph, hygrograph, triple register (for sunshine, wind direction and wind velocity) with battery and wiring, weather vane, anemometer, rain gauge, psychrometer, two maximum and four minimum thermometers and a sunshine recorder.

With these instruments the first really thorough and serious year's work in investigating Cape Cod frost conditions, in their relations to cranberry culture, was carried out. An unusually large number of frosty nights during the first part of the season, especially in June, favored this investigation, and as a result much valuable information was accumulated. It now seems that it may in time be possible to forecast frosts with gratifying accuracy. The Southern Massachusetts Telephone Company has considerably improved its distribution of the frost warnings sent out from Boston by the district forecaster of the Weather Bureau. In addition to these warnings the substation has undertaken to make special early evening forecasts for the benefit of any who may wish to telephone in for them on doubtful nights. It is not expected that the growers will place full reliance on these forecasts at present, but it is hoped that they may be of assistance in case of doubt, and that they may in time become fully reliable. However, there is so much at stake when a bog promises a good crop that it will probably be best for the growers to provide themselves with the necessary instruments and learn to make their own forecasts, because there is such a variety of conditions in different parts of the Cape.

The season's records seem to show that the early evening dew point, which has been shown to be of no value as an indicator of the minimum night temperature in some parts of the country, can be relied upon to a considerable extent in forecasting such temperatures on the Cape. The records further seem to show that the best indications that a frost may be expected on any night during the usual period of frost danger are the following: —

1. Low dew point (50° F. or below at substation shelter).
2. High (above 30) and rising barometer.
3. An all day's wind from a northerly, northeasterly or northwesterly direction, dying out in the early evening.
4. A clear sky.
5. A low maximum day temperature.
6. A low and falling early evening temperature.

The readings of the maximum and minimum thermometers and the amount of precipitation were telegraphed to the office of the United States Weather Bureau at Boston every morning after April 25 during the spring and fall periods of frost danger.

2. Frost Protection.

Because of the failure of a circulating pump, it was impossible to carry out tests with the Skinner system, as had been planned, during the spring frost period. Certain apparent disadvantages connected with the use of this system for frost protection have been discovered. In the first place, the pump and engine required for supplying water under the necessary pressure for a system covering several acres are more expensive than at first supposed. The Skinner Irrigation Company states that it is necessary to sprinkle most crops with water every two minutes during a frosty night in order to afford sufficient protection. It seems possible, however, that the injury caused by frost may be prevented by sprinkling the frosted plants with water at about sunrise, and so drawing the frost out of them gradually before the heat of the sun strikes them. Frost injury appears to be caused not by the freezing but by too rapid withdrawal of the frost. If this is true, it may be possible to sprinkle a cranberry bog with the Skinner system, or some other similar system, a section at a time, and so provide protection for the whole bog with an engine and pump only large enough to pump water for one section. Experiments have been planned to test the practicability of this method.

Another drawback to the Skinner system is the clogging of the nozzles. This gave much trouble in the small system installed at the station bog, and market gardeners who have had long experience with this system meet the same difficulty. Because of this it is now planned to test another system, which has been devised for the same purpose, with rotating nozzles set far apart and large enough to allow small particles in the water to pass through them instead of clogging.

Two extensive tests with 65 3-gallon Hamilton orchard heaters were carried out in the late fall and early winter. These tests showed that it is possible to raise the temperature sufficiently to protect from frost by means of these heaters, but the expense connected with their use seems to be so great that this method of protection cannot be considered practicable with fuel oil at the present price. The heaters were loaned to the substation by the Hamilton Orchard Heater Company, through the courtesy of its local agent, Mr. Chester D. Holmes of Plymouth, Mass.

3. Fungous Diseases.

As in previous years, this work was carried on in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture. Dr. C. L. Shear of that Bureau has done much laboratory work and has had general supervision of the spraying experiments, having kept in touch with the work on the bogs by several trips to the Cape. Co-operative spraying tests were carried on by several growers. The five plots, each four rods square, which were sprayed in the season of 1911, as reported in the last annual report of the station, were sprayed again in 1912 on dates and with fungicides as follows: —

TABLE I.

FUNGICIDE.	Plot A.	Plot B.	Plot C.	Plot D.	Plot E.
Bordeaux mixture, . . .	June 28	June 28	June 29	June 29	June 29
Bordeaux mixture, . . .	July 17	July 17	July 18	July 18	July 18
Neutral copper acetate, . .	August 5	August 5	August 6	August 6	August 6

The Bordeaux mixture was made up of 3 pounds of lime and 4 pounds of copper sulfate to 50 gallons of water. One pound of the neutral copper acetate was used to 50 gallons of water. Two pounds of resin fish-oil soap were used with the Bordeaux mixture in all cases and with the acetate.

The crop was gathered from these plots and their checks on dates and in amounts as follows, the quantities being given in bushels: —

TABLE II.

PLOT.	Area (Square Rods).	Date when picked.	Variety.	Quantity of Fruit (Bushels).	Quantity per Square Rod (Bushels).	Average of Double Checks per Square Rod.	Per Cent. of Increase due to Spraying.
A, . .	16	Sept. 19	Howe.	7⅛	.4453	-	144+
A check 1, .	4½	Sept. 19	Howe.	¾	.1667	.1823	-
A check 2, .	8	Sept. 19	Howe.	1 7/12	.1979		
B, . .	14⅛	Sept. 12	McFarlin.	7	.4956	-	45+
B check, .	13⅔	Sept. 12	McFarlin.	4⅔	.3415	-	-
C, . .	16	Sept. 19	Howe.	6⅙	.3854	-	86⅗
C check 1, .	4	Sept. 19	Howe.	⅞	.2187	.2065	-
C check 2, .	12	Sept. 19	Howe.	2⅓	.1944		
D, . .	16	Sept. 12	Early Black.	10⅓	.6458	-	47⅗
D check, .	8	Sept. 12	Early Black.	3½	.4375	-	-
E, . .	16	Sept. 7	Early Black.	7¾	.4844	-	55+
E check 1, .	8	Sept. 7	Early Black.	2½	.3125	.3125	-
E check 2, .	4	Sept. 7	Early Black.	1¼	.3125		

It will be noted from this table that the results of the spraying were far more marked with the Howe variety than with either of the others. Moreover, Plot A showed a much greater increase than the other Howe plot. The only difference in the treatment of the two Howe plots was that Plot A was sprayed three times during 1911, while Plot C, as well as the other plots, was sprayed only twice.

Where two checks were laid out for the same plot (as noted in the above table) they were in every case located on opposite sides of the sprayed area. The berries were all picked with scoops. It should be borne in mind that the increases recorded above were obtained in spite of considerable mechanical injury done in the process of spraying. The spraying was done with a 30-gallon wheeled-barrel outfit, and the injury was much greater than it would have been had a power outfit been used, it being serious enough to be plainly noticeable on the vines, on parts of the plots, at picking time.

It should be noted here that the fungus plots showed no increase in quantity of fruit over their checks last year, and this may perhaps be taken to indicate that the effects of annual spraying are cumulative.

The increase in quantity of fruit on the McFarlin plot was accompanied by a much more light-colored and sickly appearance to the foliage than was shown by the vines of the check plot. The contrast between the sprayed and unsprayed vines in this respect was noticeable by the 1st of September, and very marked after the crop was picked, being plainly evident to the eye from a long distance. A redder and more sickly color was also distinctly evident on the two Early Black plots as compared with the surrounding unsprayed vines, but the contrast was not nearly so great as with the McFarlin plot. No such difference was apparent on the Howe vines, possibly because it was hidden by the naturally very dark color of their foliage. The McFarlin and Early Black vines seemed to show that there was not sufficient available plant food present to maintain a strong vine condition and at the same time develop the extra amount of fruit which the reduction of fungous diseases by the spraying had made possible. Possibly the effects of fungus spraying are often limited by such a lack, and combination experiments with fungus spraying and fertilizers have been planned to determine this point.

When the fruit was gathered no distinct difference in color between the berries from the sprayed plots and their checks was observed. The berries from Plots A and C were somewhat larger than those from their checks, as shown by the following averages of counts of berries of 6 cupful samples (New England Cranberry Sales Company's inspector's cup) from each plot and its check, the samples being in each case taken as evenly as possible from the various boxes: —

		Number of Berries.
Plot A.	Average of first 6 samples,	100
	Average of second 6 samples,	105
Check A.	Average of first 6 samples,	110
	Average of second 6 samples,	104
Plot C.	Average of first 6 samples,	104
	Average of second 6 samples,	108½
Check C.	Average of first 6 samples,	112
	Average of second 6 samples,	111

The berries from the McFarlin plot showed practically no difference in size from those of the check, as is evident from the following averages of 6 samples taken in the same way: —

		Number of Berries.
Plot B.	Average of first 6 samples,	67
	Average of second 6 samples,	72
Check B.	Average of first 6 samples,	68
	Average of second 6 samples,	71

Of the Early Black plots, Plot D and its check showed practically no difference in the sizes of their berries, as is shown by the following averages of counts of 6 samples: —

		Number of Berries.
Plot D.	Average of first 6 samples,	110
	Average of second 6 samples,	109
Check D.	Average of first 6 samples,	111
	Average of second 6 samples,	109

The berries from Plot E were distinctly smaller than those from its checks, as is shown by the following averages: —

		Number of Berries.
Plot E.	Average of first 6 samples,	120
	Average of second 6 samples,	123
Check E.	Average of first 6 samples,	113
	Average of second 6 samples,	109

It should be noted here that the time of picking, apparently, had something to do with the relative size of the berries from these plots and their checks, for Plot E, picked on September 7, produced smaller berries than its checks, and Plots B and D, picked on September 12, produced berries of the same size as their checks, while Plots A and C, picked on September 19, produced larger berries than their checks, a gradation according to dates, irrespective of variety, thus being evident. This was perhaps caused by a retardation in the development of the fruit on the sprayed vines, due to the heavier crop which they were producing.

The keeping qualities of the berries from these plots and their checks were tested, with the results shown in the following table: —

TABLE III.

PLOT.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after Screening (Boxes).	Percentage of Loss.
A,	Oct. 3	Dec. 16	3	2 5/8	12 1/2
Check A,	Oct. 3	Dec. 16	2	1 1/2	25
B,	Oct. 11	Dec. 16	2 2/3	2 7/64	21
Check B,	Oct. 11	Dec. 16	2 1/3	1 9/16	33
C,	Oct. 11	Dec. 17	4	3 19/32	10
Check C,	Oct. 11	Dec. 16	2 2/3	2 7/64	21
D,	Oct. 11	Dec. 16	3	2 17/32	15 3/5
Check D,	Oct. 11	Dec. 16	2 2/3	2 3/16	18
E,	Oct. 11	Dec. 16	3 1/3	2 23/32	18 2/5
Check E,	Oct. 11	Dec. 16	2 1/3	1 13/16	22 1/3

The boxes used were bushel boxes, but a few slightly smaller boxes got mixed in and were not noticed until too late, causing an error to creep in which undoubtedly affected the percentages somewhat, though it is impossible to say how much. The berries were run through the separator at the beginning of the tests, but were not screened until the final screening on December 16 and 17. For these tests the berries of the two checks of those plots which had double checks (A, C and E) were mixed to form a single check for each plot.

It will be noted that Table III. shows a much greater improvement of keeping quality, due to the spraying, with the Howe berries (A and C) than with either the Early Blacks (D and E) or the McFarlins (B). This and the distinctly greater increase in quantity of fruit on the Howe plots indicate the presence of a special diseased condition, affecting that variety, which was either much less in amount or absent altogether on the McFarlins and Early Blacks. While there was much more hypertrophy ("false blossom") on the Howe vines during the first part of the summer than on the vines of the other varieties, it does not appear that this was the cause of the difference in the results obtained from spraying, for it has not been shown that spraying affects this disease. The difference seems to have been due to the presence of a hitherto unknown disease (as Dr. Shear has determined) which, for convenience, we will tentatively call the "blossom end rot." This disease was the most evident cause of decay among the Howe berries from the station bog in the fall of 1911 and also of 1912. It was only occasionally found, however, on the berries of the other varieties. Its characteristic effect on the fruit is to cause it to rot, beginning at the blossom end and working gradually toward the stem end, the berry becoming soft but remaining plump and watery, as the decay progresses. In an early stage of this rotting a characteristic, yellowish brown discoloration appears at or near the blossom end of the berry and remains there without much extension until the whole berry becomes soft. That the presence of this disease was the cause of the difference in the results obtained by spraying is shown by the following averages of counts of decayed berries in samples taken at random from the boxes of the storage tests (6 samples examined for each average), classified according to the apparent primary causes of the decay: —

TABLE IV.

[These examinations and counts were made on November 12.]

CAUSES OF DECAY.	PLOT A.		CHECK A.		PLOT C.		CHECK C.	
	First Average.	Second Average.	First Average.	Second Average.	First Average.	Second Average.	First Average.	Second Average.
Blossom end rot,	1⅔	3	6	1½	1	1	5	9
Injury,	–	1	3	1½	1	3	–	2
Doubtful,	2⅓	2	1	2	1	1½	–	3

Table III. indicates that Plot E and its check had larger percentages of loss in the keeping tests than did Plot D and its check. That this was true is also shown by the average counts of decayed berries in samples examined on November 11 given in the following table: —

TABLE V.

	Plot D.	Plot E.	Check D.	Check E.
Number of samples taken,	12	12	12	12
Average counts,	4⅙	7½	7½	9½

It might be thought that the difference here noted was due to the earlier picking of Plot E and its check, the greener fruit, perhaps, not keeping as well as that left on the vines until more mature. Close inspection of the results given in Tables II. and III. does not, however, sustain this view. Table III. indicates an improvement in keeping quality for Plot E of about 17⅗ per cent. over the check, while Plot D showed an improvement of only 13⅓ per cent. over its check. This, together with the fact that E gave an increase of 55 per cent. in quantity of fruit over its check while D gave an increase of only 47⅗ per cent., indicates that the greater amount of decay, among the berries from E and its check, in the keeping tests was due to the presence of a greater amount of fungous disease on that portion of the bog. The tests appeared to give no evidence that the stage of ripeness at which the berries were picked had any effect on their keeping quality.

Effect of Resanding on Prevalence of Fungous Disease.

A part of the station bog was resanded in 1911, and most of the remainder in the spring of 1912, with about half an inch of sand. Two Early Black plots (O and V) of 9 square rods each were left unsanded as an experiment, O being located on a portion of the bog sanded in the fall and V on a part sanded in the spring. Checks were laid out on three sides of each of these plots, and in both cases they averaged a distinctly smaller quantity of fruit per square rod in the 1912 crop than did the plots themselves. This difference was perhaps caused by the injury done to the vines in the process of sanding. The keeping qualities of the berries from these plots and their checks were tested with the results given in the following table: —

TABLE VI.

PLOT.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after Screening (Boxes).	Percentage of Loss.
O,	Oct. 3	Dec. 13	$1\frac{2}{3}$	$1\frac{7}{17}$	$15\frac{3}{10}$
Check O,	Oct. 3	Dec. 14	2	$1\frac{9}{16}$	$21\frac{9}{10}$
V,	Oct. 3	Dec. 13	2	$1\frac{11}{16}$	$15\frac{3}{5}$
Check V,	Oct. 3	Dec. 13	2	$1\frac{5}{8}$	$18\frac{3}{4}$

The same error crept into the measurement of these berries as that noted in connection with Table III. The berries were handled throughout in the same way as were those from the fungus spraying plots. The results seem to indicate that resanding favors fungous diseases.

As a check on the results obtained from the screening, shown in Table VI., the results of examination and counts, given in Table VII., are of interest. These counts were made on November 16. Each number given in Table VII. is the average of the counts of the decayed berries in 6 samples, taken in the same way as with the berries of the fungus spraying plots.

TABLE VII.

	Plot O.	Check O.	Plot V.	Check V.
First average of 6 samples, ...	6	10½	3½	5½
Second average of 6 samples, ...	9½	11	2½	10

These results seem to indicate that spring sanding favors fungous development more than does fall sanding. In this respect, the result is the reverse of that obtained from screening.

4. VARIETIES.

Investigations looking toward the possible production of new and more desirable varieties were continued. The uprights which had been marked on account of their prolificness in 1911 were found in 1912 to be, as a rule, either dead or barren. Only two or three of them bore more berries than the average, and these berries were much below the average in size. Because of the experience with these uprights an attempt was made to discover some of the more certain marks of cranberry prolificness. It now seems that the most noticeable and evident of these marks is the tendency and ability of the uprights of certain varieties to put out new uprights as branches, and at the same time develop from 3 to 5 berries each. A large number of such branching uprights were marked for examination next season. If they do exceptionally well it is planned to use the more prolific ones for planting. It should be noted here that the varieties most grown (Early Blacks, Howes, etc.) seldom produce branches on berry-bearing uprights.

In the fall, for the first time, tests of the comparative keeping qualities of certain varieties were made, and some interesting results were obtained which may eventually be of considerable value.

5. BLOSSOM FERTILIZATION.

The 1911 experiment of shutting out all bees from a small area of vines, during the blooming period and for some time afterwards, was repeated on another part of the bog in 1912. The screen was put in place over this area before a single blossom had opened and kept there until the last part of August.

Strange to say, the enclosed area bore about half as large a crop, per rod, as the surrounding bog. This result appears to contradict partially the results obtained in 1911, and for this reason it is planned to repeat the experiment again in 1913. A few small, solitary bees, or even honey bees or bumblebees, may have worked their way through the netting without being observed and visited a part of the blossoms.

The plot from which bees were excluded in 1911 has in all other respects always been treated like the surrounding bog. It is therefore of special interest to note that in 1912 this plot bore over twice as large a crop per square rod as the average of the rest of the bog, and a considerably larger one than any other equal area on the bog, the fertilizer and fungus plots included. In 1911 this area bore a very light crop in comparison with the rest of the bog. This seems to show that the after effects of light or heavy cropping often appear the following season. It is very desirable to determine to what extent this is true, for if it can be established that such effects generally do appear in the crop of the succeeding season, it must have a strong bearing on the management of cranberry bogs in more than one respect. If these effects are carried over, the apparent importance of keeping bees to insure good blossom fertilization is, in general, much reduced, for what a bog fails to produce in years of bee scarcity, on account of poor fertilization, it will tend to make up in years of bee abundance.

The keeping quality of the berries from this 1911 plot was tested, in comparison with the berries from some of the fertilizer plots. The results of the test were as follows: —

TABLE VIII.

PLOT.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after Screening (Boxes).	Percentage of Loss.
1911 Bee Exclusion Plot, ...	Oct. 11	Dec. 16	$\frac{1}{3}$	$\frac{26}{96}$	$18\frac{3}{4}$
Fertilizer Plot 22, ...	Oct. 11	Dec. 14	2	$1\frac{7}{16}$	$28\frac{1}{8}$
Fertilizer Plot 21, ...	Oct. 11	Dec. 14	2	$1\frac{3}{8}$	$31\frac{1}{4}$
Fertilizer Plot 20, ...	Oct. 11	Dec. 16	2	$1\frac{1}{2}$	25
Fertilizer Plot 1, ...	Oct. 11	Dec. 14	$1\frac{1}{3}$	$\frac{7}{8}$	$34\frac{3}{5}$
Fertilizer Plot 2, ...	Oct. 11	Dec. 14	2	$1\frac{13}{32}$	$29\frac{7}{10}$

These fertilizer plots were located near the bee plot and are here arranged in their order of proximity to that plot, 22 being the nearest and 2 the farthest away. Plot 22 is separated from the bee plot by not more than its own width, and 2 is not more than 8 rods away. Plots 1, 21 and 22 are all check fertilizer plots, and have been treated in all respects like the surrounding bog. The results indicate that the bee plot berries for some reason were much better keepers than were the berries of the surrounding bog.

The average counts of decayed berries in several samples taken from each of these plots give evidence of the general accuracy of the results shown in the above table. They were as follows: —

TABLE IX.

	1911 Bee Plot.	Fertilizer Plot 22.	Fertilizer Plot 21.	Fertilizer Plot 20.	Fertilizer Plot 1.	Fertilizer Plot 2.
Number of samples taken, .	4	8	8	8	8	8
Average counts, ...	8	16	18½	10½	20	14½

These counts were made between the 14th and the 22d of November.

The comparatively small percentage of loss among the bee plot berries shown in Table VIII. is surprising, in view of the fact that for some reason there was evidently a greater loss caused by the collapse of berries injured by fruit worms in this lot than in those from the fertilizer plots. In general, these results may perhaps be taken to indicate that the berries of a heavy cranberry crop will, other conditions being the same, keep better than those of a light

The berries from this bee plot showed other peculiarities as follows: —

First. — A marked comparative softness resembling the softness often characteristic of russet apples in the spring due to loss of water during long storage. This was so evident that the screeners noticed it at once on changing from other berries.

Second. — A large proportion of berries with rough areas on them, somewhat resembling the russeting of apples. These areas are peculiar to berries of the Early Black variety, being only occasionally found on Howes and McFarlins. Counts of berries having such areas in samples taken from different plots and varieties are given in the following table, as knowledge concerning this may havé value: —

TABLE X.

PLOT.	Variety.	Number of Samples taken.	Berries with Rough Areas.	Berries without Rough Areas.
1911 Bee Exclusion Plot, . .	Early Black, . .	3	49	68
			58	60
			55	56
Fertilizer Plot 22, . . .	Early Black, . .	2	26	73
			30	81
Fertilizer Plot 15, . . .	Early Black, . .	3	14	86
			13	78
			11	79
Plot B, ...	McFarlin, . . .	1	4	66
Check B, ...	McFarlin, . . .	1	7	72
Plot C, ...	Howe, . . .	1	6	89
Check C, ...	Howe, . . .	1	9	96
Plot D, ...	Early Black, . .	2	27	77
			33	70
Check D, ...	Early Black, . .	2	31	67
			28	78
Plot E, ...	Early Black, . .	1	18	90
Check E, ...	Early Black, . .	1	20	101

Note the much larger proportion of rough berries from the bee plot as compared with those from any of the other plots. Note also the much smaller proportion of such berries produced by fertilizer Plot 15 as compared with the other Early Black plots. Plot 15 was treated in 1911, and again in 1912, with 200 pounds of nitrate of soda, 400 pounds of acid phosphate and 200 pounds of high-grade sulfate of potash. Plot 22 was a check plot without fertilizer. Plots B, C, D and E were the sprayed fungus plots already discussed. The fact that the fruit from D and E was practically the same in this respect as that from their checks tends to indicate that the roughness was not caused by fungous disease. In the opinion of the writer it was caused (as is the russeting of apples) by the deposition of corky tissue in the skin of the fruit. Dr. Shear, in examining berries with these rough areas, found no fungus in connection with them. The difference, shown in Table X., between Plots D and E was probably due to the difference in the time of picking the berries.

These rough areas are usually more abundant among berries grown on "hard bottom" than among those grown on peat. Berries grown on "hard bottom" are usually, other conditions being the same, better keepers. This well-known fact, together with the experience with the berries from the bee plot here noted, suggests that the roughening of the fruit here discussed may be relied upon to some extent as an indicator of the keeping quality of Early Black berries. The fruit of the Late Howe variety is sometimes streaked with irregular, vein-like, red lines during ripening, and these lines appear to be of the same nature as the rough areas on the Early Black fruit, for they are most prevalent, as a rule, on berries grown on "hard bottom," and occasionally rough areas are associated with them, the roughness being superficial while the red veining is deeper within the tissues.

6. FERTILIZERS.

The Waquoit experiments were not continued, though the plots were examined just before harvesting and were found without exception to have produced a very light crop. There was apparently no evidence of any cropping effect from the fertilizers used in the preceding seasons.

The plots on the station bog at East Wareham were fertilized again, with the results shown in Table XI. The fertilizers were applied on June 25 and 26. The berries were all picked with scoops on September 11 and 12. They appeared so uniform in color and so alike in most other respects that no records were made, except those concerning their quantity, size and keeping quality. Storage tests were carried out with berries from all the plots, beginning October 11 and ending December 13 to 17, the results of which gave no evidence that any of the fertilizers, except perhaps the acid phosphate, had affected the keeping quality in any way whatever. There seemed to be somewhat less loss, as a rule, among the berries from the plots treated with phosphate (alone or in combination) than among those from the plots on either side of those so treated. The results in this connection, however, were not very positive.

TABLE XI.

PLOT.	Fertilizer used.	Quantity of Fruit obtained (Boxes).	Size of Berries; Average Number in 8 Samples.
1, ...	-	1⅞	109
2, ...	N	3¼	108
3, ...	P	2	105½
4, ...	K	1¾	112
5, ...	-	1¾	105½
6, ...	NP	3⅐	108½
7, ...	NK	3⅞	102
8, ...	PK	2¾	106½
9, ...	-	2⅓	110
10, ...	NPK	4	104
11, ...	NPKL	3½	105½
12, ...	NPKcl	3⅖	99
13, ...	-	2½	108½
14, ...	$N_{1\ 1/2}$ PK	4⅚	105
15, ...	N_2 PK	6⅑	102½
16, ...	$NKP_{1\ 1/2}$	5⅔	103½
17, ...	-	3⅙	106½
18, ...	NKP_2	5½	102
19, ...	$NPK_{1\ 1/2}$	4	106½
20, ...	NPK_2	4⅕	103½
21, ...	-	3	105½
22, ...	-	3⅛	106
23, ...	-	2	106

Plots 1, 5, 9, 13, 17, 21, 22 and 23 are all untreated check plots. The meanings of the fertilizer symbols used are as follows: —

N means 100 pounds nitrate of soda per acre.
P means 400 pounds acid phosphate per acre.
K means 200 pounds high-grade sulfate of potash per acre.

L means 1 ton of lime (slaked) per acre.
KCl means 200 pounds muriate of potash per acre.
$N_{1\,1/2}$ means 150 pounds nitrate of soda per acre.
N_2 means 200 pounds nitrate of soda per acre.

In combinations they mean, for example, as follows: N_2PK = 200 pounds of nitrate of soda + 400 pounds of acid phosphate + 200 pounds of high-grade sulfate of potash per acre.

The nitrate of soda evidently had a marked effect in increasing the quantity of fruit. As is shown by the figures in column four of Table XI. (the average sizes of the berries were inversely proportional to these figures), the variation in size between the berries from the different plots was not very great. The increases in quantity were evidently due for the most part to an increase in the number of the berries, the increase in their size being a minor factor. The potash caused no increase in fruit and the phosphate but very little. If the lime had any effect, it was detrimental. The boxes used in measuring this fruit were bushel boxes. The area of each of these plots is 8 square rods.

While the vines showed more growth on the plots to which the nitrate was applied than on the rest of the bog, this growth was not more than is desirable. There seem to be indications that the degree of drainage during the growing season has an influence on the action of nitrogenous fertilizers in their effects on fruit production and vine growth.

7. Insects.

The total cranberry insect injury of 1912 was greater than is usual on Cape Cod. The damage done by the fruit worm was more than in any season for four or five years before. The blackhead cranberry worm (fireworm) did greater and more general injury than in any season before for many years. The span worm caused serious injury for the first time in several years, destroying the crop and all the foliage on the greater part of the Old Colony bog at Yarmouth. The scale insect (*Aspidiotus oxycoccus* Woglum), discussed in last year's report as having done serious injury on a bog in Yarmouth, disappeared almost entirely, having been destroyed, apparently, by the winter flowage. It now seems evident that winter flowage is sufficiently detrimental to this pest to control it entirely, without any other treatment, if it is applied regularly every year and is held until May. The insect got its foothold on the Yarmouth bog in a season following a winter during which the bog was not flowed.

By correspondence the writer learned of serious injury on some Long Island bogs due, apparently, to the work of spittle insects, though it seems probable that other causes may have been contributory. The experience of the managers of these bogs indicates that complete reflowing for a day or two, when these insects are at work, will drive them out satisfactorily, and also that contact poisons may be used against them with considerable success where water for flowage is not available.

That the gypsy moth was abundant on bogs in places, especially in North Carver, was shown by the specimens sent in for determination.

The experimental insect work was confined mostly to the fruit worm and the blackhead cranberry worm (fireworm), though observations on the girdler ("root worm") were also made.

The Fruit Worm (*Mineola vaccinii* (Riley)).

Investigations concerning the effect of weather conditions at different seasons on fruit worm abundance were started, and the results of this work indicate the possibility of forecasting seasons in which great injury may be expected from this insect.

Late holding of the winter flowage is the surest method of controlling this insect so far known. The year's observations indicate that it is probably best to hold this flowage late (until May 25) every other year instead of every third or fourth year, as has been heretofore recommended. This is certainly true, if the effects of light and heavy cropping are generally carried over from one season into the next, as indicated by the results obtained on the 1911 bee experiment plot, for the reduction in the crop of one season, caused by the late holding of the water, will be largely made up the following year. This treatment is sure to greatly reduce the fruit-worm injury for the years of early withdrawal as well as for the years of late holding. Moreover, it seems probable that much of the fruit reduction, caused by ordinary late holding of the winter flowage, is really due to increased fungous injury, which might be largely prevented by proper spraying.

Early putting on of the winter flowage does not appear to affect the fruit worm much. A 10-acre bog, which lost most of its crop by this insect in 1911, was flowed for the winter on October 5, and the flowage was not let off until May 8. Even after this long flooding the fruit worms destroyed about 50 per cent. of what would otherwise have been a good crop.

Spraying, as a fruit-worm remedy, is still of doubtful practicability and probably always will be. The need of such a treatment, however, is not very great, for, as already stated, this insect can be treated with water where winter flowage is available, and the total acreage of bearing bog which cannot be winter-flowed at a reasonable expense is a very small percentage of the total bog area of the Cape. Moreover, most bogs which cannot be winter-flowed at a reasonable pumping expense are not and never were good business propositions for various reasons, and should never have been built in the first place. However, as there are a few such bogs which will pay a moderate return if the fruit worm is kept within bounds, it seems desirable if possible to find some treatment other than winter flowage for this insect.

A patch of 9 square rods on a dry bog badly infested with this insect was resanded on May 23 to a depth of 1 inch, the uprights being raked up through the sand when covered by it. It was thought that such sanding, while the insect was dormant in its winter cocoon, might smother it, as it does the girdler, so that the millers would not emerge during the following summer to lay eggs for another brood of worms. The sanded area was surrounded with a mosquito netting fence 8 feet high to keep the moths from the surrounding bog from coming onto it; but it was not closed in at the top, as it was necessary to give bees free access to the blossoms inside, and the moths, which apparently never fly up more than 5 or 6 feet from the ground, would probably not get in over the fence. Unfortunately, the new growth had started considerably when the sanding was done and, on this account, the injury to the buds was very severe, more than three-fourths of them being destroyed. Earlier sanding would have caused less injury. This experiment was only partially successful, as numerous fruit worm millers were seen inside the netting during the season, and probably 40 per cent. of the berries that developed on the sanded area were destroyed by the worms. That a large percentage of the millers was smothered is shown by the fact that at picking time there were noticeably more berries on the sanded area than on any equal area of the surrounding bog, in spite of the great injury done to the buds in the process of sanding. The amount of infestation on the bog where the sanding was done is shown in a general way by the fact that on a large part of the bog the worms destroyed all the berries after there had been a blossom and a fruit setting which should have produced not less than 60 barrels to the acre. As it seems probable that this sanding will also have some effect on next year's infestation, the experiment will be continued the coming season.

As strictly dry bogs are usually either winter-killed or badly spring-frosted about every two or three years, it seems probable that the best treatment for this insect on such bogs would be to destroy the remnant of the crop in the years when the severe injury from either frost or winter-kill occurs. This could probably be most readily done by spraying the bloom with a 20 per cent. solution of iron sulfate. The destruction of the bloom would cut off the season's local food supply for the insect, and it would naturally, for the most part, die off by starvation as a result. In most cases, this destruction of the bloom, after its severe reduction by adverse weather conditions, will not result in a loss to the grower, for, if the blossoms are left and the crop remnant is allowed to develop normally, the fruit worms, which without the interference of weather conditions would have an ample food supply, will be compelled to concentrate on the remnant, with the result that there will be little or nothing left at picking time anyway.

During the season following one in which a bog's infestation is starved out in this way, practically the only infestation present will be that which comes in from the upland, and that will probably not be very serious in most cases.

Another probable benefit from this method of treatment is that coming from not tearing up the vines in picking what little fruit might be left after the worms got through if the remnant of the bloom was not destroyed. *Probably more is lost, as a rule, through injury done to the vines, in harvesting a very light crop, than is gained by saving and marketing the berries.*

Work on fruit-worm parasites was continued, but without any definite results of general value.

The Flowed Bog Fireworm (*Rhopobota vacciniana* (Pack.)).

This insect is also known as the blackhead cranberry worm, but it will probably be more readily and generally recognized by the more distinctive name here used. It does little or no damage on bogs that are not winter-flowed. As indicated in the 1911 report, the killing or driving ashore of the natural enemies of this insect by the flowage is probably the main cause of serious infestation by it. In support of the evidence given in that report, the results of this season's collecting of bog insects seem rather convincing. Collections were made on several winter-flowed bogs of great difference in area, at different lengths of time after flooding and at different distances from the uplands, for comparison. Each collection consisted of the material gathered by 100 sweeps of a collector's net through the vines. Three separate collections were made on each day of collecting at each location selected for comparison, to make sure that the collections were truly representative of the insect life present. Comparisons between the different locations were made by separating out the parasitic and predacious forms, classifying them, counting the individuals of each class in each collection separately, and comparing the counts. The most remarkable fact learned from this was that, of all forms capable of damaging the fireworm, spiders were in all cases considerably the most numerous. Moreover, only the spiders gave really striking differences in the counts of the different collections made. The comparisons showed that the dry bog had very many more spiders and also a somewhat larger number of parasitic insects than did any of the winter-flowed bogs, even as late in the season as August 20, when the last collecting was done. A bog of 160 acres of rounded shape gave a distinctly smaller count of spiders, on all parts examined twenty-seven days after the flowage was taken off, than did a bog of 12 acres of similar shape on its very central portion sixty-eight days after the removal of the flowage. The distance from the center of the 12-acre bog to the upland at the nearest point is about 250 feet, as roughly measured by pacing. The 160-acre bog, in the material collected twenty-seven days after the flowage was taken off, gave distinctly larger counts and showed a greater variety of spiders near the upland than at the center. At the same time some kinds of parasitic insects were collected near the upland which seemed to be entirely absent at the middle of the bog. The distance from the center of this bog to the upland at the nearest point is about 750 feet, as measured by pacing.

While it is evident, therefore, that winter flowage seriously reduces the work of the natural enemies of the fireworm, especially on the large bogs, it must be remembered that in spite of this handicap they succeed in doing a great deal toward controlling this insect on all bogs and that, in the first beginnings of the most damaging infestation, only a few stragglers here and there succeed in escaping them. The escape of these stragglers is, however, a serious matter, for they increase the amount of infestation which these natural enemies must take care of the following season (a slight infestation probably coming onto the bog from the upland every year) if they succeed in keeping the pest under control. As the winter flowage comes in and sweeps away these natural enemies again, they cannot increase on the bog to meet the increase in the number of fireworms. The fireworms, therefore, tend to increase in number, while the number of their enemies tends to remain constant from season to season on account of the flowage interference (the bog is here considered as being winter-flowed, but not reflowed at a time to reduce the fireworms). When once the infestation has developed beyond the ability of the natural enemies of the insect to control it, its increase is very rapid unless artificial aids to these enemies are provided by man. Theoretically, the escape of 2 straggler fireworms one year may mean the escape of perhaps 50 the next year, and of perhaps 1,200 the third year, and of 30,000 the fourth year, and so on.

The point toward which we have been working in this discussion is this: *probably the ideal time to spray for this insect with arsenical poisons,* especially on the large compact bogs and on bogs which cannot be reflowed in June after having been winter-flowed, *is not after an infestation has fully developed and so threatens vines and crop that something must be done at once, but is before the infestation starts.* Cutting off the stragglers by spraying at the proper time every year, whether the insect appears to be present or not, will greatly retard the development of an infestation, if it does not completely stop it. Spraying for the stragglers need not be as effective as it would have to be under conditions of bad infestation, because the natural enemies of the fireworm will take care of most, if not all, of the worms which escape the poison. Unless the work of spraying for a heavy infestation is extraordinarily thorough and effective, there will be left, at best, a far greater number of unharmed worms than their natural enemies can begin to cope with.

Some will probably object to this method of treatment on the ground of expense. This, however, does not seem to be a valid objection when we consider that the prevention of the loss of a single average crop will make up for the expense of four good sprayings each year for a period of ten years. Then, too, as our spraying experiments, discussed in this report, have shown, most bogs should probably be sprayed several times each year to control fungous diseases. The fireworm spraying may be done at the same time, by using an excess of lime in making the Bordeaux mixture and adding a pound of Paris green to every 50 gallons, at an additional annual expense of perhaps $3.50 per acre.

While the prevention of infestation by this insect is important, it is necessary to consider how a fully developed infestation may be most easily cleaned out. As indicated in last year's report, the most serious obstacle usually encountered in ridding a bog of a bad infestation is the length of the hatching period, especially of the eggs that produce the first brood. This period seems to be much prolonged on bogs with thick vines, probably because the vines so shade the eggs on the lower leaves that their development is much slower than that of the eggs which, placed on the tops of the vines, are more exposed to the sun. In extreme cases, which are not uncommon, the hatching period is so much prolonged that there seems to be no time during the year when eggs of either the first or the second brood are not present in considerable numbers. When this period is not too much prolonged, it is often possible, at least on small bogs, to control a heavy infestation fairly well with either a single good spraying or a single early June reflowing.

The most successful treatment with water, all conditions considered, which the writer knows of, was applied on one of the large bogs during this season. The winter flowage was held until the 2d of June, from which date the bog was without flowage or any special treatment until the 25th of the same month, when it was completely reflowed for two days. Before this reflow the bog was heavily infested, but after it only a very few fireworms were seen throughout the season. This bog is compact in shape and covers about 160 acres. A considerable portion of it is heavily vined, and the infestation was spread pretty well over it. The most reasonable explanation of the success of this treatment appears to be the following one: —

In the water of the winter-flowage there was perhaps not so great a difference in temperature between the tops and the bottoms of the vines, especially where they were thick, as there would have been had they been exposed to the air as well as to the sun. Under these conditions all the fireworm eggs present were perhaps influenced in their development much more equally by the rising temperature of the spring days than they would have been without the flowage. The eggs were probably thus brought nearly to the hatching condition fairly well together, and then the water was taken off so that in this condition they were at once exposed to the hot weather of June, which naturally hastened rapidly the remaining development of all of them. By this means the hatching was so bunched up that when the bog was reflowed twenty-three days after the winter flowage was let off practically all the eggs, on thick vines as well as on thin ones, had hatched, and the insects were almost entirely in the caterpillar (worm) stage, the stage in which they are most readily drowned.

Possibly this method of treatment will not always prove as successful as it did in this case, but the conditions attending this trial were such that the results should probably be considered significant. This method should be tried further where badly infested bogs can be reflowed in June. Moreover, if the reasons given above for the success of this treatment are correct, it seems probable that spraying for a heavy infestation of this insect would be most successful if it were done after first bunching the hatching of the eggs by holding the winter flowage late. If the water is held late, the first spraying should be all done within a week after the flowage is taken off.

There is little doubt that any bog can be freed from this pest by treating it as a strictly dry bog for a few years (*i.e.*, not flooding it at any time under any conditions), thus allowing the natural enemies of the insect to accumulate against it, and at the same time spraying at proper times with arsenical poisons. The danger of loss from winter-kill and from fruit-worm infestation is, however, considerable under such conditions and must not be overlooked.

Small bogs can probably be rid of infestation by thorough spraying without omitting winter flooding.

The season's observations indicate that spiders (of several different species) and Tachina flies are the most numerous and useful of the natural enemies of the fireworm. Spiders attack and destroy the worms, and some of the jumping species have been seen to leap into the air after the millers. The Tachina flies lay the white eggs often seen on the worms, especially on and near their heads.

The Cranberry Girdler (*Crambus hortuellus* (Hübner)).

The season's observations on this insect sustain in every particular the conclusions concerning it reached in the past two years. A serious infestation by this insect, at least on a bog of small or medium size, is almost a certain sign of neglect. It apparently never succeeds in getting a foothold on bogs which are kept well sanded. Resanding every other year is usually sufficient to prevent infestation by it. Badly infested bogs almost invariably have an accumulation of old leaves over the sand under the vines, and usually the worst infestations are on heavily vined bogs.

There are indications that the girdler is often favored by man's flooding operations in the same way that the flowed bog fireworm is favored, — *i.e.*, by the destruction or driving ashore of its natural enemies. Winter-flowed bogs which cannot be reflowed appear to be more often seriously infested than do strictly dry bogs. It seems probable that neglect invites infestation by this insect because of the protection from its natural enemies afforded by the accumulation of dead leaves and other débris. Resanding covers up this material and probably compels the girdler worms to work under more exposed conditions.

Reflowing for a week or ten days right after picking is still a standard remedy for this insect where sufficient water is available.

8. Miscellaneous.

In addition to the work already discussed, sanding and picking experiments have been started. In the former, the results of no resanding are being compared with those of resanding every year, every other year and once in three years. In the picking experiments hand picking is being compared with scoop picking and early picking with late picking, in their effects on the vines and on crop production. These experiments must be carried on for several years before very definite results from them can be reported.

Experiments to determine the effects of different weather conditions on the "setting" of the fruit were also started. A general weather record was begun with the idea of ascertaining the effects of different weather conditions at different seasons on cranberry growth, fruit production, insect enemies and fungous diseases.

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TWENTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART II.,

BEING PART IV. OF THE FIFTIETH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1913.

ENDING THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTIETH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE

AMHERST, MASS.

TWENTY-FIFTH ANNUAL REPORT.

Part II.

SUMMARY OF LEADING CONCLUSIONS.

FRED W. MORSE, ACTING DIRECTOR.

During the past eighteen years 371 varieties of potatoes have been tested. In all cases the varieties have been tried two successive years, and in the second year the seed has invariably been selected from the home-grown product of the previous season. The majority of the new varieties have proved inferior to the old standard sorts like Beauty of Hebron, Early Rose, Green Mountain and Irish Cobbler.

Varieties which have given high yields in more than one two-year test are Carman No. 1, Enormous, Simmon's Model, Steuben, New Satisfaction, Red River Early Ohio, Houlton Rose, I. X. L., Daughter of Early Rose, Rose No. 9, Dutton's Seedling, Fillbasket, White Elephant, Restaurant, Thorburn, Vanguard and Woodbury's White.

Eighty-two samples of seed were tested during the year for purity and freedom from weed seeds. Timothy gave an average purity test of 97 per cent., red clover, 97.6 per cent., red top, 98.4 per cent., alsike clover, 96.2 per cent., white clover, 94.8 per cent., and other seeds were equally good, although only one or two samples of a kind were received.

It has been found that different seed laboratories sometimes report widely varying results of germination tests, when they have worked independently upon samples from one large lot of seed. It has also been found to be difficult for the seed analyst to identify accurately different seeds so closely related as cabbage and cauliflower, while the identification of seeds of different varieties of one species is almost out of the question.

A simple tool has been devised for planting white-pine seed, by which the seeds may be quickly and easily inserted in the soil without waste of seed or back-breaking exercise.

The chestnut blight is working up through the Connecticut valley, making this region the worst infested of any portion of the State; but very few old trees with rough bark are found infected. There is an unusual amount of deterioration and dying out of chestnut, which is in no way related to the blight.

One or two applications of a solution of arsenate of soda will permanently kill weeds on tennis courts and poison ivy around trees and walls. It can be best applied with a sprinkling-pot to which is attached an apron to direct the spray.

Plantain and dandelions in lawns are not readily killed by cutting off the crowns, as a large percentage of plants are apt to renew their growth in a short time.

Frequent applications of fertilizers to lawns is an aid to suppression of weeds by promoting the growth of grasses. Pulverized manure is apt to introduce weed seeds if it is used instead of chemical fertilizers.

Mosaic disease of tobacco ("calico") is not a so-called "germ disease," but is due to a disturbance of the natural balance of forces within the plant. It is infectious and may be communicated from one diseased plant to another. Seed beds should either be properly sterilized by steam or allowed to grow to grass for a year or two if seedlings have shown the disease. Injury to the roots of plants when transplanting is a frequent cause of the development of the disease, and if a diseased plant is handled during the setting there is danger of a large number of plants being infected by the hands of the planter.

An exact record of the cost of food used in milk production, has been kept for years at the experiment station. Since 1908 the average annual cost for food has been $99.52 per cow, and practically 4 cents per quart for milk. To this amount must be added the cost of care and housing. In a comparison of oats with corn as a cattle food it has been found that the oats increased the food cost of milk about 3.5 per cent. over the cost where corn was used. It is believed that oats are not an economical food for milk production in this State.

At times potatoes are plentiful and cheap, and farmers have used them as food for stock. Complaints have been received at the experiment station that when potatoes have been fed they have caused a shrinkage in milk flow and other undesirable results. Experiments were tried which showed that potatoes may be used advantageously up to an amount of 25 pounds daily per cow.

Experiments with molasses as a food for live stock have shown that it does not improve the digestibility of the other foods which must be fed with it. Nevertheless, it is a cheap food, useful in fattening animals and in making rough fodder more palatable; but in comparison with corn meal, molasses possesses no advantages in price or efficiency. Molasses feeds should be carefully considered with regard to guarantees and cost in comparison with other concentrates before they are purchased.

Experiments with beet pulp have shown it to be an economical and efficient food for milk production when it can be purchased for a lower price than corn meal. Milk producers who purchase all their grain will find dried beet pulp a satisfactory component of the grain ration, up to one-half of the total mixture.

Several instances of failure of greenhouse crops, particularly cucumbers, have been brought to the attention of the experiment station. Analyses of the soil have shown it to be overloaded with soluble fertilizer, in comparison with soil in which the crops have made a normal growth. This overloading may have been due to too heavy dressing with manure and chemicals, or to unsatisfactory drainage, which permitted an accumulation of salts that in the favorable soil were leached out during the season.

The refuse tobacco stalks on an acre of tobacco have been found to contain over 87 pounds of nitrogen, 132 pounds of potash and 20 pounds of phosphoric acid, worth about $24 when compared with other standard waste vegetable matter like castor pomace. The common practice of spreading the stalks on the field to be leached by the rain and snow recovers a little more than half of the nitrogen and potash and practically none of the phosphoric acid. The stalks should be cut or shredded and plowed under, so that all the fertility may be recovered, while over 1¼ tons of vegetable matter may be incorporated with the soil to form humus.

During the year nearly 400 different insects were inquired about by the people at large. The season was especially favorable for the development of plant-lice, and over a hundred separate inquiries were received regarding these insects.

The discovery, in a box of celery from California of 50 individuals of a species of lady beetle belonging on the Pacific coast shows how injurious insects also may be imported and added to our list of garden pests.

Tests of new insecticides did not show them to be in any way superior to established kinds.

A VARIETY TEST OF POTATOES.

E. F. GASKILL.

During the last eighteen years the agricultural department of the experiment station has tested 371 varieties of potatoes. This work has brought out many interesting facts. It will not be possible in this article to go into all the details of the work, but the general plan and some of the more interesting facts will be given.

General Plan. — There have been in all cases two trials, — a preliminary test and a final test. The varieties selected each year for trial have been those advertised by different seedsmen and recommended to the public because of their superior merits. Small amounts of seed have been obtained from these firms and planted in one of our fields to produce seed for a second-year test. Thus for the second trial we have had home-grown seed that has been raised and stored under precisely the same conditions for every variety. During the preliminary tests records have been kept, but all of our conclusions are based upon results obtained in the second-year tests.

We have included in each trial, for the sake of comparison, some of the standard varieties, such as Beauty of Hebron, Green Mountain, Early Rose and Irish Cobbler.

Soil. — In most instances these trials have been made on a medium loam with a gravelly subsoil, affording good drainage and an ideal potato soil.

Fertilizers. — A home-made mixture has been used, furnishing the elements of plant food in about the following proportions: —

	Per Cent.
Nitrogen,	2½ to 4½
Phosphoric acid,	6 to 10
Potash,	8 to 10

Seed. — The original seed has come from widely different sources, but that used in the second-year tests has always been of our own raising. The practice has been to cut the tubers into pieces, having two eyes each and of as nearly equal size as possible. The seed has usually been treated for scab with either corrosive sublimate or formalin (two ounces of corrosive sublimate to 15 gallons of water, or one-half pint of formalin to 15 gallons of water).

Spraying. — Careful attention has been given to this phase of the work, using both a fungicide and an insecticide several times during the season.

A Few of the Varieties Grown.

In each of the following cases the five varieties giving the best yield are mentioned in the order of their superiority, and the five varieties giving the poorest yield are mentioned in the order of their inferiority.

In 1896, 60 varieties were grown, 14 of which gave yields of over 275 bushels per acre and 4 less than 150 bushels per acre.

Best. — Carman No. 1, Dutton's Seedling, Early Maine, Fillbasket, New Satisfaction.

Poorest. — Early Ohio, Polaris, World's Fair, Sir William, Alexander's Prolific.

In 1898, 25 varieties were grown, 11 of which gave yields of over 200 bushels per acre and 5 less than 150 bushels per acre.

Best. — White Elephant, Fillbasket, Enormous, Woodbury's White, Thorburn.

Poorest. — Early Maine, Bliss's Triumph, Dakota Red, Empire State.

In 1899, 94 varieties were grown, 48 of which gave yields of over 300 bushels per acre and 3 less than 200 bushels per acre.

Best. — Fillbasket, White Elephant, Washington, Howard, Enormous.

Poorest. — Empire State, Olgoma, Commercial, Hurst, Mills Long Keeper.

In 1902, 33 varieties were grown, 10 of which gave yields of over 250 bushels per acre and 4 less than 150 bushels per acre.

Best. — Beauty of Hebron (first generation from Maine seed), Beauty of Hebron (second generation from Maine seed), I. X. L., Steuben, Early Nancy.
Poorest. — Livingstone, Stevens, The June, Ford, 1902, Smith's Six Weeks.

In 1904, 49 varieties were grown, 12 of which gave yields of over 250 bushels per acre and 4 less than 150 bushels per acre.

Best. — Simmon's Model, Extra Early White Rose, Great Divide, Steuben, Maxima.
Poorest. — Kaiser Krone, White Ohio, Sweet Home, King of Ohio, Clinton.

In 1906, 25 varieties were grown, 4 of which gave yields of over 200 bushels per acre and 4 less than 100 bushels per acre.

Best. — Simmon's Model, Climax, Chenango White, Hammond's Wonderful, Gortsap.
Poorest. — Banner, Noroton Beauty, Short Seasons, Good as Gold, Uncle Gideon's Quick Lunch.

In 1907, 41 varieties were grown.

Best. — White Mountain, Green Mountain, Violet Mammoth, Green Mountain (Early Dying Tops), Manistie.
Poorest. — Imperial Early Ohio, Dan Patch, Fast Mail, Early Six Weeks, May's Netted Gem.

In 1909, 46 varieties were grown, 9 of which gave yields of over 275 bushels per acre and 5 less than 150 bushels per acre.

Best. — Burbank, Quaker City, Great Bonanza, Wilson's First Choice, Ionia Seedling.
Poorest. — Dew Drop, Snow White, Salzer's Prosperity, Perfection, Blush.

In 1911, 31 varieties were grown, 6 of which gave yields of over 200 bushels per acre and 12 less than 150 bushels per acre.

Best. — Red River Early Ohio, Good News, White Victor, Jumbo, Late Hebron.
Poorest. — 1910 Seedling, Early Bovee, Saxony, Sunrise, Surprise.

The following varieties have been included in two of our two-year tests and given very satisfactory yields each time: —

Carman No. 1, Enormous, Simmon's Model, Steuben, New Satisfaction, Red River Early Ohio, Houlton Rose, I. X. L., Daughter of Early Rose, and Rose No. 9.

The following varieties have been included in three of our two-year tests and given very satisfactory yields each time: —

Dutton's Seedling, Fillbasket, White Elephant, Restaurant, Thorburn, Vanguard, Woodbury's White.

Beauty of Hebron and Early Rose have been included in six of our two-year tests, and always stood among the ten or twelve best varieties each year. Some years they have stood among the first five.

The Green Mountain has been included in three of our two-year tests and has always given a very satisfactory yield.

A FEW OF THE INTERESTING FACTS BROUGHT OUT.

1. The rate of yields obtained have been from 66 to 509 bushels per acre.
2. The same variety is sometimes sold under more than one name.
3. The majority of the new varieties are inferior to the old standard sorts, like Beauty of Hebron, Green Mountain, Early Rose and Irish Cobbler.
4. Several good varieties have been discovered from the standpoint of both yield and quality.
5. Results obtained in the preliminary tests do not correspond with the results obtained in the second-year tests.

6. In testing varieties of potatoes it is absolutely essential to use seed that has been grown and stored under similar conditions. To prove this statement the following test was made: —

Seed of two standard varieties — Beauty of Hebron and Early Rose — were secured from several different sources. The source of seed and the results obtained are shown in the following table quoted from the report of the agriculturist in the eleventh annual report of this station: —

Comparison of Seed Potatoes from Different Localities (Yield in Pounds of 40 Sets).

Source of the Seed.	Varieties.			
	Beauty of Hebron.		Early Rose.	
	Merchantable.	Small.	Merchantable.	Small.
Home grown,	30.0	2.5	25.0	2.9
Guelph, Ontario,	32.3	1.8	–	–
Pennsylvania grown, Dreer,	24.5	3.3	27.5	3.5
James J. H. Gregory, Marblehead, Mass.,	35.5	2.5	–	–
Cornell Experiment Station, Ithaca, N. Y.,	29.3	2.5	31.0	2.0
Wisconsin, Olds Seed Company,	26.0	4.5	–	–
Maine, A. H. Weeks Company,	33.3	2.8	–	–
Dibble Seed Company, New York,	26.5	3.8	32.5	2.0
Minnesota, Farmer Seed Company,	–	–	21.0	3.8
Kansas, F. Barteldes & Co.,	–	–	20.0	7.8

7. Northern-grown seed is preferable to home-grown seed.

8. Many varieties advertised by seedsmen as being extra early or extra large yielders are found to be late and inferior in regard to yield.

9. From our observations the following varieties appear to be identical: —

King of the Earliest and Early Ohio.
Salzer's Earliest and Bliss's Triumph.
Miller's Banner and Livingston's Banner.
White Beauty and Cambridge Russet (almost identical).
Hammond's Wonderful and Rough Rider.
Million Dollar and Mark Hanna.

In discussing variety tests of potatoes in the fifteenth annual report of the experiment station, Dr. Brooks concludes as follows: —

> It is firmly believed that it is much wiser that potato growers shall secure seed of standard varieties grown and stored under the best conditions, than to pay high prices for new varieties, which in so many instances when carefully tested under the fairest possible conditions are found not to equal the older sorts either in productiveness or in quality. In our experience seed grown in northern Maine has invariably been found to be superior to that of our own production, even in the first generation. The Maine seed gives the larger yield, and the crop is somewhat earlier. It usually costs somewhat more than home-grown seed, but it is richly worth the greater price.

Preliminary Test, 1912.

During the past year, seed of nineteen varieties of potatoes was obtained from widely different sources. The seed was treated for scab, cut and planted in the usual way. The yields ranged from 91 bushels to 312 bushels per acre. The varieties grown were: —

Buckbee's Extra Early Rockford.
Clyde.
Diamond.
Early Six Weeks.
Early White Albino.
Farmer Potato.
Gray's Mortgage Lifter.
Green Mountain.
Johnson's Early Flour Ball.
Northern Star.
Quick Crop.
Sir Walter Raleigh.
Six Weeks.
Snow.
Sutton's Early Monarch.
The Early Surprise.
The Irish Cobbler.
The Petoskey.
Trust Buster.

In 1913 the second-year test will be made of these varieties using the seed grown in this year's test.

SEED WORK FOR THE YEAR 1912.

G. E. STONE.

The seed work for 1912 has included as usual seed germination, separation and testing for purity. There were 285 samples of seed sent in for germination, onion and tobacco leading the list. The average germination of onion seed for 1912 was 75.3; the highest being 95 per cent. and the lowest 7 per cent. The average for tobacco was 51.9; the highest 98 per cent. and the lowest 0. Last season (1911) the average germination of onion seed was 70 per cent.; the highest, 98 per cent., and the lowest 20 per cent. For tobacco the average was 84 per cent.; the highest, 95 per cent., and the lowest, 21 per cent. The average germination for onion seed was slightly below that given for a number of years, and that for tobacco was much less, due no doubt to the effects of frost on the seed.

Records of Seed Germination for 1912.

Name of Seed.	Number of Samples.	Per Cent. of Germination.		
		Average.	Highest.	Lowest.
Onion,	104	75.3	95.0	7.0
Tobacco,	50	51.9	98.0	0.0
Clover,	29	86.4	99.0	55.0
Grasses,	29	85.2	97.5	20.5
Cabbage,	10	57.0	85.0	6.0
Carrot,	9	59.3	90.0	34.0
Oats,	7	83.1	98.0	50.0
Sweet pea,	7	23.7	85.0	4.0
Turnip,	5	63.8	91.0	0.0
Corn,	4	46.6	63.0	37.0
Beet,	3	77.7	91.0	70.0
Squash,	3	49.7	62.0	41.0
Miscellaneous,	25	38.6	96.0	0.0
Total,	285			

The number of pounds of seed separated is not so large as last year, although the number of samples is greater. The total number of pounds separated was 1,517, about 1,300 pounds of it being onion seed. The percentage of seed discarded was from 11 to 19 per cent., the largest amount being discarded from lettuce seed. Practically all the lettuce seed received for separation is sent in by the market-gardeners around Boston.

Records of Seed Separation, 1912.

Name of Seed.	Number of Samples.	Weight (Pounds).	Per Cent. of Seed retained.	Per Cent. of Seed discarded.
Tobacco, ...	81	51.37	88.70	11.30
Onion, ...	54	1,298.62	88.10	11.90
Lettuce, ...	6	133.62	80.06	19.94
Celery, ...	4	1.38	86.40	13.60
Beet, ...	1	27.56	81.60	18.40
Radish, ...	1	5.51	83 20	16.80
Totals, ...	147	1,517 88		

The number of purity tests made during the year was 82, the seed coming in some cases from farmers, and in others from seed merchants. Occasionally farmers buy their seed, or decide not to, on the strength of these tests.

More purity tests were made of timothy than of any other seed, 17 samples being tested, followed by 11 for red clover and 11 for red top. The total number of species of foreign seed found in these tests was 51, 34 being regarded as noxious and 17 as harmless. These foreign seeds are by no means abundant, and are often difficult to remove even by the most improved methods of seed separation.

Records of Seed Purity Tests, 1912, made by E. A. Larrabee.

[Figures in parentheses indicate number of samples in which corresponding seed is found.]

NAME OF SEED.	Number of Samples.	PER CENT. PURITY.			KIND OF WEED SEEDS FOUND AND NUMBER OF SAMPLES IN WHICH FOUND.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Timothy, . .	17	99	83.3	97.0	Pepper grass (5). Sheep sorrel (4). Lamb's quarters (5). Wild teasel (3). Cerastium sp.? (3). Chickweed (1). Potentilla sp.? (3). Ox-eyed daisy (1). Plantain (3). Yellow foxtail (1). Mustard (1). Curled dock (1). Knot grass (1).	Red top (5). Alsike clover (8). White clover (3). Poa sp.? (6). Red clover (3). Blue grass (1).
Red clover, . .	11	99	96.0	97.6	Plantain (8). Curled dock (3). Shepherd's purse (1). Chickory (1). Twistle (2). Wild carrot (2). Lady's thumb (1). Lamb's quarters (3). Barnyard grass (1). Charlock (1).	Alsike clover (2). Timothy (4). Alfalfa (4). Medic (3). Crimson clover (1). Red top (1).
Red top, . .	11	99	94.7	98.4	Sheep sorrel (4). Curled dock (2). Chickweed (1).	Timothy (3). Blue grass (1).
Oats, . . .	4	99	98.5	98.8	Mustard (1). Yellow foxtail (1).	Corn (1). Wheat (3).
Alfalfa, . .	5	99	97.0	98.4	Plantain (3). Lamb's quarters (2). Sheep sorrel (1). Green foxtail (2). Yellow foxtail (1). Bindweed (1). Chickory (1). Thistles (1).	Red top (1). Poa sp.? (1). Medic (1). Panicum sp.? (1).
Alsike clover, .	8	98	95.2	96.5	Mustard (1). Gum plant (1). Sheep sorrel (3). Lamb's quarters (3). Ox-eyed daisy (1). Chickory (1). Self-heal (1). Plantain (2). Chickweed (1). Yellow foxtail (1). Curled dock (3). Shepherd's purse (2). Thistle (1). Pepper grass (1). Seed unidentified (1).	Red clover (7). Timothy (7). Rabbit-foot clover (1).
White clover, .	7	99	90.7	94.8	Sheep sorrel (6). Dock (1). Plantain (4). Chickory (1). Bouncing Bet (1). Crane's bill (1). Yarrow (2). Seed unidentified (2).	Medic (2). Alsike (3). Red clover (2). Red top (1). Timothy (2). Wild buckwheat (1).

Records of Seed Purity Tests, 1912, made by E. A. Larrabee— Concluded.

[Figures in parentheses indicate number of samples in which corresponding seed is found.]

NAME OF SEED.	Number of Samples.	PER CENT. PURITY.			KIND OF WEED SEEDS FOUND AND NUMBER OF SAMPLES IN WHICH FOUND.	
		Maximum.	Minimum.	Average.	Noxious.	Harmless.
Kentucky blue grass.	3	98	96.0	97.0	Sheep sorrel (2). Lady's thumb (1). Plantain (1). Seed unidentified (1).	Red clover (2). Sweet clover (1). Alsike clover (1). Timothy (1). Red top (1).
Alfalfa clover, .	2	99	98.0	97.0	Yellow foxtail (1). Thistle (1).	Red clover (1).
Millett, . .	4	99	99.0	99.0	Lady's thumb (2). Curled dock (1). Plantain (1). Charlock (1). Penn Persicaria (2). Lamb's quarters (1).	
Rhode Island Bent,	3	97	96.0	96.7	Sheep sorrel (2). Switch grass (1).	Timothy (1).
Wood meadow, .	2	98	96.0	97.0	. . . . .	Sweet clover (1).
Mammoth clover,	1	99	99.0	99.0		
Medium clover, .	1	99	99.0	99.0	Sheep sorrel (1). Lady's thumb (1).	
Lawn grass, . .	3	–	–	–	Sheep sorrel (2). Plantain (3). Buttercup (3). Curled dock (1). Pepper grass (2). Amaranthus sp.? (1). Chickweed (1). Field dodder (1). Seed unidentified (1). Dandelion (1).	

In this table rib grass and bracted plantain were put under the one title, "plantain."

The standard of purity frequently adopted for timothy is 98 per cent.; for red clover, 98 per cent.; for red top, 95 per cent.; for oats, 99 per cent.; for alfalfa, 98 per cent.; for Alsike clover, 95 per cent.; for white clover, 95 per cent.; for Kentucky bluegrass, 90 per cent. Nineteen samples of timothy gave an average purity test of 97 per cent.; 11 samples of red clover, 97.6 per cent.; 11 samples of red top, 98.4 per cent.; 4 samples of oats, 98.8 per cent.; 5 samples of alfalfa, 98.4 per cent.; 8 samples of Alsike clover, 96.2 per cent.; 7 samples of white clover, 94.8 per cent.; 3 samples of Kentucky bluegrass, 97 per cent.

It is clear that these seeds are of very high grade, some of them being much better than the standard required. Many of the so-called noxious weeds are of little importance with us and make slow headway in a well-seeded field, even Canada thistle, which greatly concerned the farmers many years ago, having become a relatively rare pest.

All samples of seed to be tested or separated should be sent to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass., and the freight or express should be prepaid.

SOME VARIABLE RESULTS OF SEED TESTING.

G. E. STONE.

The enactment in several States of various seed control laws, many of which are strict, has offered opportunity to study the accuracy of our whole system of seed testing. It has often been a question, particularly among the seed dealers, whether we are in a position to pass and enforce stringent seed laws. Accompanying the laws there is usually given a standard for the purity and germinating capacity of seeds. If seeds are improperly labeled, contain certain noxious weed seeds or fall below the standards given, according to the phrasing of some laws the seed dealer is liable to a fine.

Very different results are often obtained in seed-testing laboratories, it often requiring duplicate tests to obtain anything approaching the true averages. The results given in the following six tables were obtained by a large seed firm which collected a number of typical samples from bulk and sent them to several seed-testing stations for examination. The tables include tests of timothy, millet, Kentucky blue grass, orchard grass, alfalfa and red clover. The numbers in the first column of each table indicate the different seed-testing stations; for example, in the case of red clover, 19 different laboratories reported, and in nearly all cases germination and purity tests were made of each seed.

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages).

Red Clover.

Seed-testing Station.	Purity Test.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
1,	99.02	.80	.180	90.0
2,	99.15	.59	.260	87.5
3,	98.10	1.70	.200	84.0
4,	–	–	–	92.0
5,	98.40	1.20	.400	89.5
6,	–	–	.030	88.8
7,	99.50	.20	.300	95.0
8,	98.97	.68	.350	98.0
9,	99.70	.20	.100	84.0
10,	99.00	.80	.200	86.0
11,	98.70	.90	.400	–
12,	–	–	–	91.0
13,	98.50	.10	.400	85.0
14,	97.80	1.80	.400	94.0
15,	99.00	.99	.002	91.0
16,	98.88	.94	.180	93.0
17,	99.75	–	–	96.0
18,	98.90	.40	.700	96.0
19,	99.30	.40	.300	90.0
Average,	98.91	.73	.278	90.8

Timothy.

Seed-testing Station.	Pure Seed.	Inert Matter.	Foreign Seed.	Germination Test.
1,	99.43	.35	.220	93.0
2,	99.41	.49	.100	96.7
3,	98.50	.40	.100	95.0
4,	–	–	–	93.0
5,	99.60	.30	.100	94.5
6,	99.00	.70	.300	90.0
7,	99.90	.05	.045	97.0
8,	99.60	.20	.200	86.0
9,	99.30	.50	.200	94.0
10,	99.30	.30	.400	–
11,	–	–	–	89.0

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages) — Continued.

Timothy — Concluded.

SEED-TESTING STATION.	PURITY TEST.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
12,	99.40	.20	.400	92.0
13,	99.50	.25	.250	92.0
14,	99.90	trace	trace	97.0
15,	-	-	-	90.0
16,	99.25	.30	.450	91.0
17,	99.76	-	-	94.0
18,	98.20	.10	1.700	90.0
19,	99.50	.30	.200	89.0
Average,	99.35	.30	.343	92.4

Millet.

SEED-TESTING STATION.	Pure Seed.	Inert Matter.	Foreign Seed.	Germination Test.
1,	96.33	.45	3.22	93.0
2,	98.15	.22	1.63	90.0
3,	98.00	.20	1.80	87.0
4,	-	-	-	95.0
5,	98.20	.40	1.40	90.5
6,	-	-	3.43	92.9
7,	97.20	.50	2.30	99.0
8,	98.37	.20	1.43	99.0
9,	98.80	trace	1.20	93.0
10,	97.40	.20	2.40	94.0
11,	98.10	.40	1.50	-
12,	-	-	-	95.0
13,	98.20	.40	1.40	92.0
14,	98.08	trace	1.92	92.0
15,	97.40	.40	2.20	89.0
16,	98.60	.20	1.20	94.0
17,	97.55	-	-	96.0
18,	97.10	.30	2.60	90.0
19,	98.30	.40	1.30	96.0
Average,	98.48	.32	1.93	93.1

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages) — Continued.

Kentucky Blue Grass.

SEED-TESTING STATION.	PURITY TEST.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
1,	88.15	11.55	.30	88.0
2,	78.90	21.10	.00	58.0
3,	89.00	10.60	40	78.0
4,	72.00	–	–	28.0
5,	84.70	15.00	.30	39.0
6,	–	–	.01	24.0
7,	86.60	13.00	.40	70.0
8,	99.59	.40	–	15.0
9,	99.60	.40	trace	–
10,	84.00	15.60	.40	66.0
11,	95.60	3.60	.80	–
12,	–	–	–	68.0
13,	78.40	21.50	.10	–
14,	96.90	3.10	trace	6.0
15,	–	–	–	73.0
16,	84.00	15.79	.20	78.0
17,	96.50	3.00	.50	7.5
18,	97.83	–	–	3.0
19,	98.70	1.10	.20	81.0
20,	83.80	16.00	.20	88.0
21,	–	–	–	32 (check)
Average,	84.36	10.11	.29	54.0

Orchard Grass.

SEED-TESTING STATION.	Pure Seed.	Inert Matter.	Foreign Seed.	Germination Test.
1,	76.48	23.37	.15	81.0
2,	75.69	23.32	.99	82.0
3,	81.30	18.00	.70	91.0
4,	74.00	–	–	69.0
5,	74.50	24.50	1.00	70.0
6,	–	–	.07	69.2
7,	84.50	15.00	.50	76.0
8,	99.40	.40	.20	60.0
9,	97.60	2.00	.40	–
10,	77.00	22.20	.80	80.0

Table showing Purity and Germination Tests made at Different Seed-testing Stations of Seed taken from the Same Bulk (Data given in Percentages) — Concluded.

Orchard Grass — Concluded.

SEED-TESTING STATION.	PURITY TEST.			Germination Test.
	Pure Seed.	Inert Matter.	Foreign Seed.	
11,	93.90	5.30	.80	–
12,	–	–	–	86.0
13,	78.10	21.00	.90	81.0
14,	–	–	–	61.0
15,	76.50	23.50	–	59.0
16,	77.45	21.47	1.09	86.0
17,	–	–	–	65.0
18,	94.00	5.00	1.00	72.0
19,	93.17	–	–	50.0
20,	98.20	1.40	2.00	89.0
21,	90.60	8.60	.80	64.0
Average,	84.73	14.33	.76	73.2

Alfalfa.

SEED-TESTING STATION.	Pure Seed.	Inert Matter.	Foreign Seed.	Germination Test.
1,	99.20	.52	.280	99.0
2,	99.33	.43	.240	94.0
3,	98.50	1.40	.100	95.0
4,	–	–[1]	–	98.0
5,	99.00	.30	.100	95.0
6,	–	–	.080	96.0
7,	99.10	.30	.600	93.0
8,	99.46	.27	.262	97.0
9,	99.20	.60	.200	92.0
10,	97.30	2.40	.300	97.0
11,	98.80	1.00	.200	–
12,	–	–	–	96.0
13,	99.40	.60	.200	95.5
14,	97.20	2.80	–	98.0
15,	94.10	5.90	–	99.0
16,	–	–	–	93.0
17,	98.82	1.00	.180	96.5
18,	99.86	–	–	98.0
19,	97.90	1.80	.300	95.0
Average,	98.47	1.37	.234	96.5

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[1] Grade No. 3.

From an examination of the data shown in the tables it will be seen that there are considerable differences in the results obtained by the various seed-testing stations. If we compare the highest and lowest percentages in each table for purity and germination tests we find the following results: the greatest variation in the percentage of pure seed in red clover was 1.7 per cent.; that for germination, 14 per cent. This sample was reported on by 19 different testing stations.

In the sample of timothy, 19 stations gave a difference of 1.7 per cent. in the purity tests and 11 per cent. for germination. In 18 station tests of millet there was a difference of 2.5 per cent. in the purity and 12 per cent. in the germination tests. Twenty-one tests of Kentucky blue grass gave a difference of 27.6 per cent. in the purity and 85 per cent. in germination tests. Twenty-one tests of orchard grass showed a difference of 25.4 per cent. for purity and 41 per cent. for germination. In the sample of alfalfa, tested by 18 different stations, there was a difference of 5.7 per cent. in purity and 7 per cent. in germination.

The maximum differences given in the purity tests are in most cases unimportant, 1 or 2 per cent. variation showing careful work; but differences of 5 or 10 per cent. or more are serious to the seedsman when he is required to conform to certain laws. This is also true of the germination tests, 2 or 3 per cent. or more being of little account, but when the differences range from 10 to 85 per cent., it is food for thought. Kentucky blue grass and orchard grass showed the greatest variations in the tests, but the purity tests, as might be expected, ran more evenly than the germination. The results given in these tables are by no means unusual, as greater differences in tests of the same sample from various seed-testing stations have previously been observed. On receiving results like these it is quite natural for the seedsman to ask what is the right course to follow, and which report he shall take as a basis for the guarantee under which he shall sell such seed as Kentucky blue grass and orchard grass. It is well known that there is a great deal of variation in the seed itself, due quite often to climatic conditions. The tests also vary greatly, even when the same methods are used, from different causes, and from the results given in these tables it would seem unjust to hold seedsmen to any rigid standard, as it would be likely to affect materially agricultural interests. For instance, the germination percentage of Kentucky blue grass ranges from 3 to 88 per cent., the average being 54 per cent., and it is a vital question to the seedsmen just what germination percentage the seed should have, as some of the lower percentages may be due to faulty methods. Too great pains cannot be taken in testing seeds for dealers when they are to be sold on merely a verbal guarantee, as there is a possibility of doing them great injustice and injuring their business.

Some of the laws which have been drawn up are rather particular as regards the proper identification of seeds, stating that they shall be true to name, etc. But it often happens that shipments of seeds which are purchased by seedsmen become more or less mixed as labels are lost in going through the custom house, and their exact identity is not always easy to determine.

Difficulties underlying Identification of Seeds.

The wide variation in the results of seed germination and purity has been previously touched upon in this article, and we now turn to a more detailed discussion of the difficulties which surround the analyst in the matter of the identification of some of the more common agricultural seeds, the horticultural or trade name of which varies from the true botanical name, especially in regard to the varieties. It is often found that a seed which has a certain botanical name is sold in the market under a distinctly different trade name; thus a great difference of opinion is found in a discussion of the seed from the legal point of view. Under a great many of our existing seed laws, therefore, a wide difference of viewpoint and application may be exercised without wilful misbranding by any one.

The following table shows this to a remarkable degree. It is concerned with the identification of certain agricultural seeds of common occurrence, and while the identification of the seeds may not be the work of the best analysts in the country, it is fairly representative.

Table showing the Relative Accuracy with which Certain Agricultural Seeds can be determined botanically.

SAMPLE NUMBER.	Horticultural Name.	Name given by Analyst.
1,	Medium clover.	Red clover.
2,	Kentucky blue grass.	Kentucky blue grass.
3,	Orchard grass.	Orchard grass.
4,	Red top fancy.	Probably red top.
5,	Swedish turnip.	Rape.
6,	Rye grass.	Rye grass.
7,	Canada blue grass.	Canada blue grass.
8,	Meadow fescue.	Meadow fescue.
9,	Fine Rhode Island bent.	Agrostis spp. (Probably neither true red top nor Rhode Island bent.)
10,	Cabbage.	Cauliflower.
11,	Witch grass.	Probably rye grass.
12,	Brown mustard.	Probably black mustard.
13,	4-rowed barley.	Barley.
14,	Creeping bent.	Red top.
15,	English rape.	Probably Brassica napus (rape?).
16,	Mammoth red clover.	Red clover.
17,	Wild mustard.	Black mustard.
18,	Spring rye.	Rye.
19,	Kohlrabi.	Rape.
20,	Winter wheat.	Winter wheat.
21,	6-rowed barley.	Barley.
22,	Cauliflower.	Cabbage.
23,	Flat turnip.	German rape.
24,	Oat grass.	Common hair grass (Deschampsia flexuosa).
25,	German rape.	Turnip.
26,	Spring wheat.	Wheat (Triticum sativum).
27,	2-rowed barley.	Barley.
28,	Winter rye.	Rye winter.

The seeds were not labeled and were simply presented for identification without any explanation of the purpose. It will be seen from a study of the table that while the greater number of the seeds are correct botanically, a much smaller number are correct according to the horticultural name and variety. Samples No. 1 and No. 16 are horticulturally "Medium Clover" and "Mammoth Red Clover," respectively, but the analyst called them simply "red clover." Both are right from their individual viewpoint, but legally, which is the proper designation? It is the same with the barleys; horticulturally, they are designated as two, four and six rowed, respectively, but the analyst has classed them as barley, simply, which is incorrect from the seedsman's standpoint, and also from the application of the seed laws in some States.

Aside from the error resulting from a cursory examination of seed by an analyst for purity, etc., it would be very difficult for one to identify the different varieties of plants from a simple examination of the seed alone, — for instance, the different varieties of cabbage, rape, wheat, etc., — as the macroscopic and microscopic characters of the different varieties are so nearly alike in many cases. Very often the only way in which a seed can be proved to be true to name is by growing the plant to maturity and getting the fruit or product which is used for identification purposes. This, of course, is out of the province of the seed inspector, and he cannot be held to an absolutely true identification of the variety, especially in the instances mentioned. Very often, also, it is necessary to have the plant for identification, as the seed structure may be quite misleading.

In the matter of the proper identification of seeds it might be stated, also, that in the case of mixtures of seeds like Canada blue grass and Kentucky blue grass, unless the analyst is very careful, the presence of one or the other may easily be overlooked. In one instance that we know of a sample of Kentucky blue grass, which contained a large amount of Canada blue grass, was analyzed by 23 different stations in this and other countries, and 12 out of the 27 stations did not report the presence of Canada blue grass. Thus it can be seen that great care should be exercised in the matter of purity tests, and only thoroughly qualified analysts should be intrusted with the work.

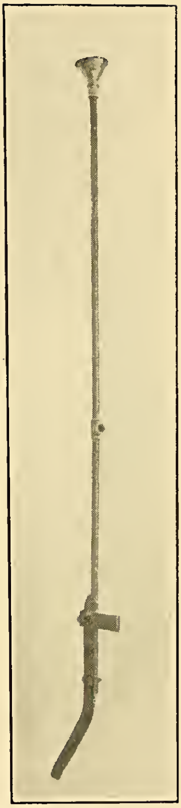

FIG. 1.—Showing device for planting white pine seed.

DEVICE FOR PLANTING WHITE PINE SEED.

G. E. STONE.

A few years ago the writer had occasion to plant some white pine seed in sod land, and the simple apparatus shown in Fig. 1 was devised for the purpose. It consists of a hollow iron tube about 5/8 of an inch in diameter, to the bottom of which is attached a bent piece of strap iron about 1¾ inches in width and thick enough to give the required rigidity. This is sharpened at one end like a chisel, and the iron handle extends to the bent part of the piece of iron. To the lower end of the hollow handle is attached a rubber tube which extends within a few inches of the end of the flat blade.

In using this device, which is designed to plant the seed easily and quickly, the chisel end or blade is thrust into the ground at such an angle that a slice of sod seldom more than 5/8 of an inch in thickness is raised. The planter is then brought to a vertical position and three or four seeds dropped into the funnel at the top. The seeds fall underneath the thin layer of sod, and then the instrument is taken out and the sod pushed back to cover the seed. This planter has been used to some extent in its original form by various persons, and no attempt has been made to improve upon it as yet. It operates easily, however, and does away with the stooping over required by the ordinary methods in use.

The general opinion among foresters is that it does not pay to plant white pine seed, and that much better results can be obtained from seedlings. It costs much less to plant seed, however, and it should be remembered that the great bulk of the white pine which has been growing in the State for centuries started from seed. It should also be pointed out that the New England States are unusually well adapted for the growing of white pine, and most of our waste land would soon be covered with this tree if left to itself. It may be true that it requires a great many seeds blown from a tree in a pasture to start one seedling, but when the seeds are planted the case is different.

The cost of planting seedlings at the present time appears to be prohibitive, and this view is taken by most of our lumbermen and farmers. Hon. J. J. Hammond of Northampton has tried both methods on his farm in Goshen, and is enthusiastic over the planting of seed.

The device shown in the illustration could be improved in some ways, and could perhaps be made lighter. It is a question whether it would be worth while to attach an automatic device for regulating the number of seed, as it is very easy to drop a few seeds from one's pocket into the funnel. Pine seed will frequently not germinate more than 30 per cent.; therefore it is desirable to plant several seeds in one spot.

CHESTNUT BLIGHT.

G. E. STONE.

This disease, already referred to in our previous reports, has been with us now for five or six years, and in some sections has become quite prevalent. It was first noticed in the vicinity of New York in 1905 by Dr. W. A. Murrill, since which time it has spread over considerable area. The writer has been observing the disease from the time it was first introduced, and has been able to watch its increase in various parts of the country. The fact that it has spread more rapidly and extensively southward than northward has led us to take an optimistic view of the continuation of its ravages in Massachusetts.

Along with the blight has been a deterioration of the chestnut tree which does not seem to be in any way associated with the blight fungus. While no attempt has been made to survey the State systematically, to learn the range of infection, our examinations of diseased material sent in to the experiment station the past few years have thrown considerable light on its distribution.

The first infections are naturally the worst, and are confined in a general way to our river valleys, — the Connecticut, Housatonic and Blackstone and their immediate neighborhoods, while the eastern central section of the State still remains comparatively free from the disease.

The chestnut blight, like the elm-leaf beetle infection, appears to be working up through the Connecticut valley in particular, and this is the worst infected region in the State. To one diseased tree found this year there will no doubt be seven or eight next year, and this is the ratio of increase each year.

The small, smooth bark trees are the ones most largely infected, the old and rough bark trees being least susceptible.

Two or three year old sprout growths easily fall a prey to the disease, more often near the base where the light is more or less excluded and where there is more moisture. In the case of old, rough bark trees the infection occurs first on the younger branches and twigs, but very few old trees are affected as compared with the younger trees in our locality. The unusual amount of deterioration and the dying out of the chestnut everywhere common, which is in no way associated with the blight, have led many to exaggerate the extent of infection from the fungus, many hundreds of trees having been pronounced infected when they were not. The real blight is surely a serious enough thing without exaggeration considering the melancholy fact that no practical and efficient remedy or even suggestion of one is in sight.

WEED EXTERMINATION.

G. E. STONE.

In recent years a great deal has been done along the lines of weed extermination, and many different methods have been experimented with and some of them adopted. There are several proprietary articles and mechanical devices on the market purporting to solve some of the phases of the weed question, but most of them are rather expensive when used on a large scale. When one needs only a small amount of weedicide, however, it is better to buy the easily procured proprietary article than to bother with the crude material, which is often hard to obtain.

Sulfate of iron has proved valuable in the west for the extermination of such tender plants as mustard and others when used as a spray in grain fields, and it can also be used for killing dandelions in lawns. It is inexpensive when bought in bulk, although the proprietary article, consisting of pulverized sulfate of iron mixed with nitrate of soda and sand and put out in expensive containers, is not so cheap. Arsenate of soda, which can be bought in bulk or as a commercial article, and similar compounds are also used as weed killers.

Of the several mechanical devices used for weed extermination, some are designed to pull up the weeds and others to kill them by injecting poisonous chemicals into the roots, while still others do the work by burning. Even electricity has been tried, but with rather unsatisfactory results, since considerable current is required to kill even small plants. Salt, copper sulfate, carbolic acid, nitrate of soda and many other materials have been used as weed killers, and undoubtedly in the future cheaper and more efficient methods will be found.

Arsenate of Soda.

Arsenical compounds appear to be the most poisonous to weeds. Of these, arsenate or arsenite of soda is usually employed, and is especially valuable for destroying weeds in dirt walks, roads, ditches and tennis courts and for killing poison ivy about trees, buildings, stone walls, etc. It is very poisonous to plants and lasting in its effects. One or two applications at the rate of 10 gallons of the solution per square rod (made up of 1 pound of the arsenate of soda to 5 or 10 gallons of water) will last for some years. This substance does not appear to leach out of the soil to any extent, while many others used as weed killers either volatilize quickly or leach out through the soil, producing only a temporary effect. Arsenate of soda can be used to advantage also in treating 4 or 5 inches of a lawn close to the foundations of buildings, to save clipping by hand the tall grass which cannot be reached with a lawn mower.

The most satisfactory way to apply arsenate of soda is by means of a sprinkler with an attachment to direct the spray (Fig. 1). With this device it is possible to treat walks up to the very edge without injuring the grass in the least. A single drop of arsenate of soda will injure any vegetation it touches, so care must be used in handling it; therefore this little attachment shown in Fig. 1 is valuable for directing the liquid. Arsenate of soda should not be used too freely near the feeding roots of trees, but we have never noticed any injury from treating walks near shrubbery or even within a few feet of large trees.

Weeds in Lawns.

To insure a heavy growth of grass and absence of weeds a lawn should have a good, deep foundation of rich soil, well supplied with organic matter and plant food. It is also important that the soil should possess the proper physical properties or texture in order to produce a good growth of grass, and it should have sufficient water-retaining capacity to enable the grass to endure drought. A soil of medium texture well provided with loam, with a water-retaining capacity of about 70 per cent., is much better than a coarse soil of less water-retaining capacity; for in seasons of drought the coarse soil will dry out very quickly and the grass will suffer, whereas the reverse is true of the fine soil. The weed proposition loses some of its importance if the lawn is well made, since a good growth of grass will crowd out the weeds. New lawns are more troubled

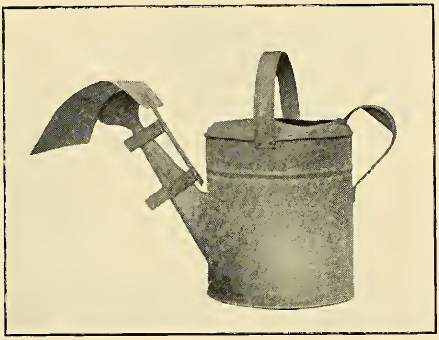

FIG. 1. — Showing watering-can with device for applying arsenate of soda.

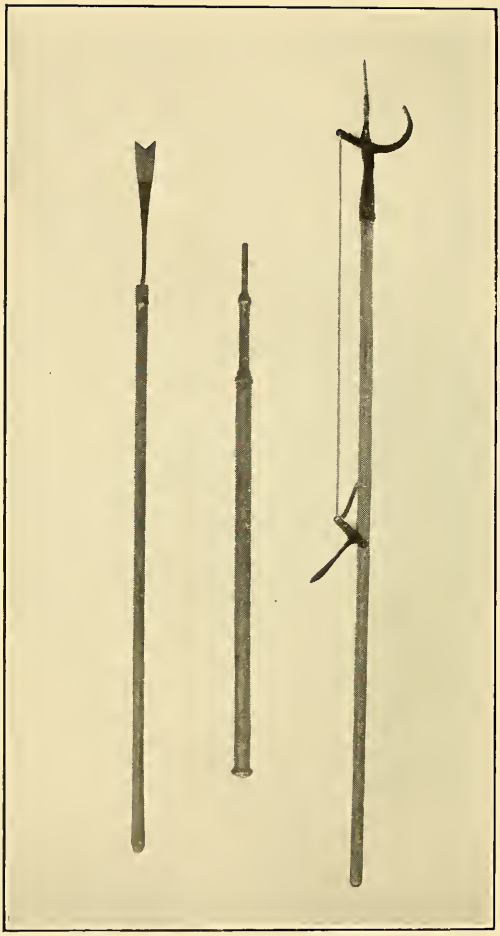

FIG. 2. — Showing different types of weed exterminators. Figure at the right, home-made device for cutting lawn weeds. Figure to the left, similar device. Figure in the center illustrates a device for injecting poisons into the roots of weeds.

with weeds on this account. One of the worst weeds affecting new lawns is crab grass (*Digitaria humifusa*), but it lasts only a year or two, as a rule. It is much more troublesome on dry lawns, where the catch of grass is poor. Frequent close cutting of the grass in the fall is a good preventive, since the seed is not allowed to mature. Two of the plantains, *P. lanceolata* and *P. major,* are troublesome in lawns, more especially where the grass is thin. Cutting plantain at different distances from the roots with a special device has not always proved satisfactory, and our observations have shown that when cut in this way a large percentage of the plants renew their growth (Fig. 2). This appears to be true, also, of the dandelion.

The following table shows the results of cutting plantain stems. The experiments were made by Mr. A. J. Sullivan, a student assistant.

TABLE I. — *Showing Results of cutting Plantain Stems* (*Plantago Major L*).

Lot.	Number of Plants used.	Method of cutting Stems.	Results.	
			Growth.	No. Growth.
A,	25	Very close to roots.	17	8
B,	25	⅛ inch from roots.	16	9
C,	25	⅛ to ¼ inch from roots.	20	5
D,	25	¼ inch from roots.	15	10
E,	25	⅛ inch from roots.	20	5
Total,	125	- - -	88	37

After being cut the plants were set out in boxes in good soil and under favorable conditions for growth. They were planted slightly below the surface of the soil to prevent the death of the cut surface. The results do not show much difference as regards distance of cutting from the roots, although those plants cut near the roots show a weak and more tardy response. Of the total number of plants cut, 88 started to produce new foliage and 37 failed to respond.

The stems of plantain are, as a rule, only about ¾ or 1 inch in length, and if cut quite deep below the surface of the ground a considerable percentage could possibly be destroyed.

The effects of the prevailing winds on plantain seed are often shown in their distribution on lawns. In winter their seed spikes are often found protruding above the snow, and when the snow has a crust the seeds are easily carried long distances, and often land at certain points corresponding with the action of the wind.

Many other weeds, when cut below the surface, will not renew their growth. The device shown in Fig. 2 consists of an asparagus cutter inserted into a handle, and is a cheap, practical and easily used tool for cutting roots below the surface.

Frequent applications of fertilizer to lawns is of some service in exterminating weeds. For this reason we have devised a lawn fertilizer spreader,[1] consisting of a holder mounted on rubber-tired wheels, with an opening ¾ of an inch in width which can easily be opened or closed while operating the machine (Fig. 3). The spreader is provided with a revolving cylinder which keeps the fertilizer pulverized and in motion. This device was designed to improve upon the clumsier method of hand spreading, and it will spread the fertilizer so evenly and thoroughly that every root can be reached. With its use more fertilizer may be required to completely cover the lawn, but a great deal is gained by the thorough application and even distribution. It is not designed to spread coarse manure, but may be used with pulverized sheep and cow manure and commercial fertilizers.

Besides using pulverized sheep or cow manure in the spring or fall, wood ashes, nitrate of soda, sulfate or muriate of potash may be applied. We have found it well to fertilize in late summer when the grass is losing its vigor, which keeps it growing and in good condition up to the end of the season, and also helps greatly to crowd out undesirable fall weeds.

Weed Seeds in Sheep Manure.

Pulverized sheep and cow manure, while excellent for lawns on account of the large amount of organic matter which they contain, do, like other manures, possess a disadvantage in the undesirable weed seeds often found in them. Most of the pulverized manures come from the Chicago stock yards, and west-

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[1] In the design and construction of this spreader the writer is indebted to M. E. A. Thompson of Amherst, whose ingenuity and skill are highly appreciated.

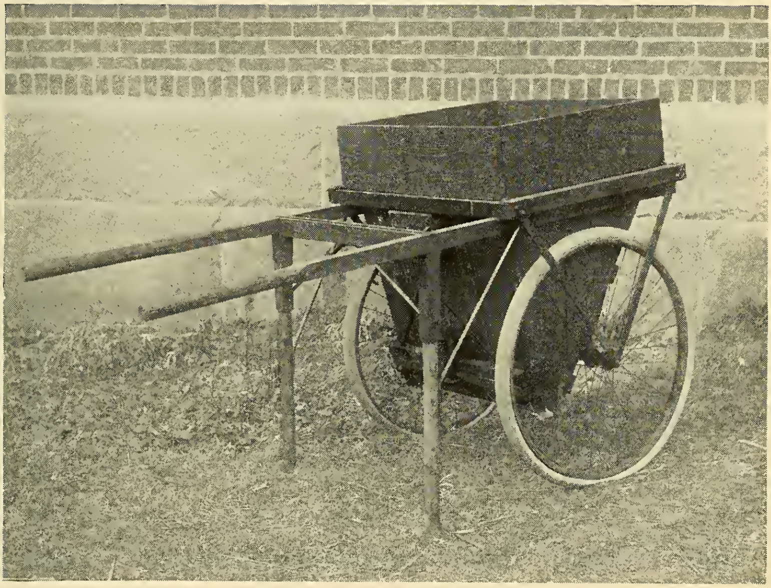

FIG. 3.—Showing fertilizer spreader for lawns.

ern seeds are likely to predominate in them. An analysis of pulverized sheep manure shows the following weed seeds in one pound: —

TABLE II. — *Showing Number and Kinds of Weed Seeds in One Pound of Pulverized Sheep Manure.*

KIND OF SEED.	Number of Seeds.
Ladies' thumb,	580
Tumble weed,	670
Sorrel,	390
Timothy,	1,000
Foxtail,	400
Panicum and other species,	820
Plantago lanceolata, etc.,	200
Total,	4,060

The figures given in this table show the great number of seeds in pulverized sheep manure, — 4,060 to 1 pound, which would be equivalent to 406,000 seeds in a 100-pound bag. But this table represents only one analysis, although taken from a typical sample on the market. Some of the seeds named are of little account, while others, like *Plantago lanceolata* and certain *Panicums,* often prove noxious. One lawn with which we have experimented, and to which sheep manure was applied freely, became badly contaminated with *Plantago lanceolata,* which had never been noticed in the lawn before and must have come in with the sheep manure. It was most abundant in the poorest part of the lawn. In another case where pulverized sheep manure was used plentifully a remarkable catch of a beautiful little lawn grass growing about 4 inches high and known as *Poa annua* was found. The seed of this grass cannot be had in the market, and yet it is one of the most desirable lawn grasses, thriving in the shade where other grasses will not. Whether the sheep manure contained the seed, or whether it merely furnished a suitable environment for its development, as does potash for clover, was not learned.

The large amount of organic matter contained in sheep manure makes it an excellent lawn fertilizer, although from the point of view of plant food contained it is more expensive than most chemical fertilizers. Still, we believe that no chemical fertilizer can take its place on lawns. The number of weed seeds it contains is its worst feature, but this might possibly be overcome by some system of sterilization.[1] The application of steam would have a tendency to increase the ammonification and would be a troublesome process, but if the weed seeds could be killed by an application of formaldehyde and potassium permanganate it would be a practical method. Fumigation with this substance will kill onion seed very quickly, but whether it would have the same effect on weed seeds we do not know.

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[1] Some brands of pulverized sheep manure are said to be sterilized.

"MOSAIC" AND ALLIED DISEASES, WITH ESPECIAL REFERENCE TO TOBACCO AND TOMATOES.

G. H. CHAPMAN.

This disease, or forms of it, has been known for several years, and various articles and papers have been prepared dealing with its description, causes, effects and methods of treatment; but the results obtained have been so varied that one hardly knows what to conclude. One authority states positively that the disease is contagious, another that it is infectious and still others that it is neither. It is our object in this paper to review in brief the results of other investigators and also the results of several years' work on our part devoted to the study of so-called mosaic disease and physiological troubles which we believe to be more or less closely allied to it.

This disease is commercially important to the layman only as it affects tobacco, and to a less extent greenhouse tomatoes (we have never found this disease produced on field-grown tomatoes except under artificial conditions of growth), which seem to be less susceptible than other plants of the Solaniaceæ. It is very important in some localities as regards tobacco, however, because a leaf attacked by it loses its elasticity, and after curing will not make a good wrapper for cigars. The results obtained and presented in this paper will deal simply with its causes, probable methods of control, etc., as regards the practical grower, but not with the physiology and chemistry of the disease from a technical viewpoint. We do not mean to imply that we have said the last word on the subject, but we have made an earnest endeavor to clear up as many points as possible regarding this peculiar disease.

We believe that several other diseases, such as peach "yellows," aster "yellows" and others, are more or less similar in character to the true "mosaic," but this paper will treat only of the "mosaic" of tobacco and tomato. Experimental data have been obtained to a certain extent on these allied diseases and will be presented in a future report.

Description of the Disease on Tobacco and Tomato.

The appearance of this disease has been described by many investigators, and nearly all have described it in a similar manner, but more particularly with reference to tobacco than to the tomato. The general characteristics of the disease are the same for both plants, but some differences are found in extreme cases in its appearance on the tomato, as will be noted from the following description: —

In the first stages of the disease the leaves of both plants present a mottled appearance, being divided into larger or smaller areas of dark and light green patches, with very regular outlines. At this point, however, no unequal swelling of the areas is noticeable, but as the disease progresses the darker portions grow more rapidly (growing normally), while the light green areas grow very slowly, and in this manner leaf distortion is brought about. In the tomato the light green areas become yellowish as the disease progresses, and in very badly affected plants become finally purplish-red in color. This coloration, however, is probably a secondary result of the disease, and is found principally on plants which are exposed to strong light, but does not occur always, as it has been found that sometimes, even in badly affected plants, the disease may reach its maximum intensity without showing any reddish coloration whatever.

The reddish appearance is noticeable only on the upper side of the leaf, and extends only through the palisade cells. A discussion of the cause of this coloration will not be taken up in this paper.

We have under no conditions ever noticed this coloration on tobacco, but occasionally in the field have seen the affected portions of leaves show brown, dead areas of tissue, a condition which may be analogous, but which we have been as yet unable to prove.

On badly diseased plants of both tobacco and tomato the leaves are much distorted and stiff, and often, especially in the case of the tomato, are very badly curled, never possessing the flexibility of healthy, normal leaves.

We have also found this disease on other plants, but have not been able in every case to obtain the same trouble by inoculating back to tobacco, and *vice versa*. A. F. Woods (1) reports this trouble as occurring on poke-weed (*Phytolacca decandra*), and U. Suzuki (2) reports a similar trouble on the mulberries of Japan caused by extreme cutting back. We have also been able to produce the disease by pruning and inoculation of plants of ragweed (*Ambrosia artemisifolia*), Jimson weed (*Datura Stramonium,* L.) and others, but we have not been able to observe it in all its characteristics on potatoes, even when severely pruned. It undoubtedly occurs on many other plants, but we should not confound it with the results obtained from overfeeding, as the appearance of these two troubles is under certain conditions almost identical.

OCCURRENCE.

On the tomato we find that the disease occurs only on plants grown in the greenhouse, or, in other words, forced plants, and most often on such plants as are pruned, seldom making its appearance on plants which are left normal. We have never observed this trouble on field-grown tomatoes, and, so far as we are able to discover, no one has observed it on such plants, probably for the reason that, as a rule, such plants are not heavily pruned. We have not been able to obtain it by pruning mildly on normal field-grown tomatoes, and the reason for this is found in the fact that the plants get a normal growth and are not forced, even though they may get a temporary excess of food materials as a result of the pruning. Forced plants, of course, are more susceptible to diseases in general, as has been proved over and over again by many investigators.

The disease as it occurs on tomatoes has from our observations very little economic importance, as it does not, as a rule, lessen the fruiting capacity of the vine or distort the fruit badly. This observation has been made time and time again in greenhouses in this and neighboring States. Occasionally, however, we do find a crop which is a failure, or individual vines which are a loss, but this is due to a lack of proper pruning or other conditions which tend to intensify the trouble. Small, nubbly fruit results, of no commercial value, and a generally stunted condition of the vine is always observed.

The disease as it occurs on tobacco is of more importance from an economic point of view, as, from the figures obtained from the United States Department of Agriculture, the annual loss in the United States alone is over $1,000,000 per annum. The trouble may appear in all stages of growth on tobacco, from the seedling to the mature plant. A great many instances are on record of the seedlings being affected in the seed bed, and we have observed it frequently in the past few years on old beds which have been used repeatedly. As has been observed by other writers, it is only occasionally that the first two leaves are affected, but often the succeeding leaves come diseased. The cause of the affection in the seed bed will be discussed later in the paper. If diseased plants are transplanted to the field they do not recover, and the whole plant becomes affected and worthless commercially. The appearance of the diseased plants in the seed bed is not so characteristic as its appearance on mature plants, but, nevertheless, they can be easily distinguished from the healthy plants. There is at first no distortion, but rather a mottled appearance of light and dark green areas which persist and do not disappear during the day, in opposition to the mottling which is frequently observed when for any reason plants are subjected to abnormal night conditions. The leaves are also somewhat roughened, which is caused by the beginning of the unequal growth of the healthy and diseased areas. When these plants are transplanted to the field we get the characteristic appearance of the disease, although sometimes they may not be severely distorted. Leaves of a plant which are not affected will not become diseased, since the disease can only be transmitted through the dividing cells, as has been shown by several investigators and verified at this laboratory.

As to the cause of this trouble much has been written by various investigators, but, as some of the earlier theories have long been proved fallacious, no discussion of them is necessary at this time. Among the later theories may be mentioned that of Beijerinck (3), who was the first to prove that the disease was effective only through the dividing cells, and held the view that the disease was caused by a liquid or fluid contagium (a definite, distinct substance having characteristic properties). This theory has not been proved, however, and the causative agent or agents are not held to be necessarily a single specialized product.

In support of Beijerinck's theory it may be said that, upon crushing the leaves or rubbing them between the fingers and then successively touching the terminal bud of other plants in the field which are not affected with mosaic, in some cases mosaic will occur on the leaves, developing after the buds have been touched. This, however, we are inclined to think is more due to the fact that the tender buds have been touched with the fingers, causing some bruising or abrasion of their cellular substance rather than to any *specialized* contagion transmitted from the diseased plant. Where the juice of diseased plants was sprayed on the terminal bud, however, we were unable to transmit the disease except in very few cases. Experiments were conducted to determine the truth of this observation, and the method of doing this has been to rub a diseased leaf between the fingers, then to touch successively the terminal buds of a number of other plants unaffected with the mosaic with the hand which had been rubbed with the diseased leaf; then on another series of plants the hand was rubbed with a leaf which had no mosaic, and the plants successively touched, without touching any plants which were affected with the disease. In a great number of cases the disease appeared on the plants which were touched with the hand rubbed with the diseased tissue, while those touched with the hand which had been rubbed with a healthy leaf were nearly all normal, only a few developing the disease. This method of infection has been used by other investigators. The infection, however, we do not believe to be caused by a specialized virus, but rather by a combination of enzymes, which view has been held by A. F. Woods, and also proved by us at this laboratory.

The direct cause may be found in the presence of free hydrogen peroxide or some other residuary by-product of plant metabolism which has been allowed to remain unassimilated in the cells of the leaves through the excessive development and retardation of certain enzymes. We have shown conclusively in previous experiments that catalase in the diseased leaves was present in far less amounts than in healthy leaves, and as it has been found and proved by Loew (4) and other investigators, principally Jensen (5), that the chief function of catalase seems to be its power of destroying free hydrogen peroxide, breaking it up into water and oxygen, and this in so powerful a manner as to be observable in the presence of the least amount of catalase, and also as there was an excessive amount of other enzymes present, of which we will speak later, we are led to conclude from the observations and experiments carried on by us that the disease is not caused by a specialized virus. There is no doubt whatever that the disease is infectious, but it may be stated with equal certainty that the trouble is not contagious.

The disease being caused primarily by the excessive action of certain enzymes and a corresponding reduction of function of others, it is easily seen that any disruption of the normal metabolism of a plant will tend to produce the disease, and also A. F. Woods has pointed out that the excess enzymes in decaying roots, etc., are able to start up these changes and so produce the disease. The more technical experiments which we have carried on supporting these views will be given in another paper.

The secondary causes are by far the most important to the grower, as in many instances he can by careful attention remove or control the conditions, especially in the seed bed. Among these causes may be mentioned too high a temperature in the seed bed, accompanied by excessive moisture or too little. Soil moisture conditions alone do not seem to be of any effect as a causative agent. This has been shown by various investigators, and was not particularly studied by us. Where the trouble shows in the seed bed and is not brought on by too high a temperature it may be due to the following causes, as has been deduced from our observations and experiments: —

The seed bed may have been used for several successive years without change or rest, and thus the soil has become inoculated with the causative enzymes; or roots and diseased plants may have been left inadvertently in the soil, and on their decay the enzymes persisted. This condition may be remedied by thorough sterilization with steam, or by using beds which have not grown tobacco before, or by letting the beds grow to grass for a year or two before using again, two years being better than one. The activity of the noxious enzymes appears to lessen during this time, and finally ceases. Although we have not verified the following in our experiments, it is stated that too high a nitrogenous soil content will sometimes cause the disease in the seed bed.

Improper sterilization of the seed bed will sometimes increase the disease for the following reasons: the soil which is improperly steam-treated renders certain of the plant foods more available, and yet does not render the enzymes inactive, and thus for a time accelerates plant growth by excessive forcing, rendering the plant more liable to attacks of disease during the period of forcing. This condition has been observed occasionally by us and can be explained on no other grounds. As a result of the improper sterilization the temperature of the soil is not raised sufficiently to kill the enzymes, and therefore they remain active in the soil. Thorough sterilization will kill enzymes, or at least two sterilizations will kill them, thus getting rid of the residuary zymogen or revivified enzyme.

In the Field.

As has been pointed out by other investigators, there are many ways of contracting the disease in the field, but it has been definitely proved that excess or lack of mineral fertilizer alone will not cause the trouble. This idea was first advanced by Meyers (6) and Beijerinck (7) who showed that the disease could not be brought on by excessive use of mineral fertilizers, although a leaf distortion due to overfeeding is quite often observed. These results were verified in our work in the laboratory and field.

One of the chief causes of the production of the disease is, without doubt, — as has been pointed out by Woods (8), Sturgis (9) and others, — improper methods or carelessness in transplanting. We are inclined to think from our observations that fully 80 per cent. of the diseased plants, particularly in this locality, may be traced to improper transplanting. It has been shown that when the roots are lacerated in any way the trouble may gain a foothold, as the metabolic or life processes are thus deranged, and a condition favorable to the disease is introduced. We have found that when the roots are broken or torn to any great extent in removing the plants from the seed bed they are often liable to become diseased. With regard to this point we may quote from a Connecticut station report: —

> In this connection Mr. Barnes of Hatfield related the following: "Young plants were taken from the same seed bed by two different farmers, and although the soil of the fields was the same, one farmer had many mosaic plants in his field and the other had almost none. Inquiry revealed the fact that one farmer took the plants from the seed bed when it was quite dry, the other when it was well moistened. In taking the plants from a dry bed one cannot help lacerating the roots, while from a well-moistened bed the roots may be drawn in an almost intact condition. Lacerated roots do not generally develop to such a vigorous state as is required by a quickly growing tobacco plant."

We made experiments in regard to this point and the above observation was verified. In the majority of cases of the dry plants a large percentage developed the disease. The remedy in this case suggests itself, that is, the seed bed should be in moist condition when the plants are removed, but not so wet as to have any adhering ball of earth on the roots; but this condition is rarely found, as very little soil remains on the roots when they are taken from the seed bed.

After the disease appears in the field it is practically impossible to control it, but it does not usually make its appearance on plants not affected in the first few weeks of growth. Mild cases of this trouble sometimes appear when the flower bud is left on, as has been shown by A. F. Woods, and the mottled appearance often shows on plants which have been topped on the subsequent growth, *i.e.*, the suckers. Soils of a compact, clayey character also sometimes induce the disease indirectly by requiring constant close cultivation to prevent packing, and as a result the roots are often lacerated, uneven growth resulting, thus bringing about abnormal changes in the processes of plant metabolism.

It is stated that broad-leaf tobacco is more liable to this disease than Havana, but we have been unable to verify this statement locally.

Shade-grown or tent-grown tobacco is said to be less liable to the disease than that grown without shade. This has been our experience and is borne out by the statements of practical growers who have grown both kinds. The conditions governing growth under shade are of course more uniform than in the field, and a more regular and slower development of the plant is brought about.

SEED.

Various investigators have pointed out that the disease is not transmitted through the seed, as it has been shown repeatedly that seed from mosaic plants will produce healthy plants and *vice versa;* also that there is no difference in the seed produced by cross pollination as regards susceptibility to the disease, and this has been so repeatedly proved as to need no verification. It is a fact, however, that the heavy seed of tobacco will produce larger, better and more uniform plants through careful selection, and as this laboratory has made a specialty of separating the seed for the growers for the last few years, observations on the prevalence of the mosaic were made among the fields each year, and it was found that growers who were having their seed separated each year had less and less trouble with mosaic, due somewhat to the selection of a more vigorous seed. Only the heavy seed was planted, and only the seed of the best plants saved; thus a process of seed selection was practiced and naturally an improvement in the quality of the plants was found. The seed is separated by a blast of air, and a detailed account of the method will be found in one of the bulletins (10) of this station. In experiments carried on at the laboratory it was found that the plants from heavy seed were less liable to the trouble than the light, discarded seed; these latter did not produce strong, healthy plants, but were weak, and thus more liable to the trouble when favorable conditions were present. It must be understood, however, that there is nothing inherent in the seed itself which would cause the trouble; it is simply a matter of getting strong, viable seed to produce vigorous plants.

REVIEW.

A more or less popular account has been given in the preceding pages of the cause, appearance and general characteristics of this interesting disease, and a later report will take up the more technical part of the work, when most of the experiments carried on will be described. At this time a brief review of the preceding pages will be given, in order to summarize the facts presented.

1. "Mosaic," "Brindle," "Calico" or "Mottle top" of tobacco is a physiological disease purely and has no fungous or bacterial origin. It is caused by the excessive activity of the oxidase and peroxidase enzymes in the plant and the partial loss of function of catalase, another enzyme, which carries off some of the residual products of the others mentioned. It is not due to one enzyme alone nor to any specialized virus.

2. It is infectious but not contagious. Care should be exercised not to touch the terminal bud of healthy plants with anything which has come in contact with diseased plants.

3. It does not occur in the seed beds when new soil is used nor in properly sterilized seed beds.

4. Improper sterilization of seed beds or old beds tends to intensify the disease if present.

5. The temperature of the beds should not be allowed to run too high for any length of time. It is better to run the bed rather cool than too hot.

6. Where a seed bed is infected it may be grown to grass for a year or two and then used again for tobacco.

7. An excess of mineral fertilizers in the field does not cause the trouble nor intensify the disease.

8. Care should be exercised when the stems are used for fertilizer that the stems of mosaic plants are not used, as they may prove a source of infection.

9. Excessively clayey soils should be avoided, especially in growing Havana tobacco.

10. Once the disease appears on a plant all subsequent growth

will be mosaic to a greater or less extent. A badly affected plant is worthless.

11. Shade-grown tobacco is less liable to the disease than ordinary field-grown, as a more uniform growth is obtained.

12. Great care should be used to remove the plants from the seed bed when the soil is moist, as thereby the roots are less liable to injury and few are broken. They should not be allowed to dry out.

13. Thorough and timely cultivation will do a great deal towards the prevention of this disease.

14. Careful seed selection and separation will also help the grower by giving him stronger and more vigorous plants.

In conclusion it may be said that if care is used and sufficient attention paid to all stages of the growth from the time the seed is planted until the plants are mature, and the results studied and acted on rationally, the amount of mosaic will be greatly lessened, and, in fact, practically eliminated from the field. It should be understood, however, that under adverse conditions, such as unsuitable soil, etc., one cannot expect to eradicate this trouble.

In a future paper will be taken up the more detailed and technical work performed by us in the study of this trouble, also additional notes on similar diseases of other economic plants.

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THE VALUE OF OATS FOR MILK PRODUCTION.

J. B. LINDSEY.

Oats are held in high esteem as a food for all classes of farm animals, and particularly for horses. They are also regarded as a valuable food for milk production, although their relative cost, especially in the east, has prevented their general use for this purpose. For example, the average wholesale price for a ton of oats in 1910 was $29.51, and for the first eight months of 1911 it was $26.99, as against $26.39 and $23.88 for corn meal.

The fact that oats are so highly regarded for the production of milk led the station to conduct three demonstration experiments with dairy cows, comparing ground oats with a like amount of corn meal.

The Composition of Oats.

	Oats fed.	Average American Analyses.[1]	Average Foreign Analyses.[2]	Corn Meal fed.	Average Massachusetts Analyses.[3]
Water,	10.80	10.40	13.30	14.50	11.00
Ash,	3.25	3.20	3.10	.86	1.30
Protein,	12.15	11.40	10.30	7.93	9.80
Fat,	4.41	4.80	4.80	5.74	3.90
Fiber,	8.94	10.80	10.30	.81	2.00
Extract matter,	60.45	59.40	58.20	70.16	72.00
Total,	100.00	100.00	100.00	100.00	100.00

[1] Henry, 1910. [2] Kellner, 1909. [3] Lindsey's Compilation, 1910.

Oats vary in composition rather more than some other cereals. The larger the per cent. of hulls, the lower the percentages of protein and fat. Oats that are imperfectly developed are likely to have relatively more protein and less starchy matter than those that have been well formed. The percentage of hulls varies between 20 and 35, with a probable average of 26. It was held formerly that they contained an alkaloid *avenin* which accounted for their peculiar effect in imparting spirit to horses, but more recent investigations have failed to identify this product. E. Schulze identified an alkaloid Trigonellum in the oat, but the amount found was so small as to be without influence as a stimulant.

The corn meal fed in the present experiment was the usual material now offered in the general markets. It evidently was not ground corn kernels, but a sifted product resulting from the manufacture of cracked corn. The analysis of corn meal given for comparison represented the average of 119 samples of ground corn kernels. It is higher in protein and fiber and lower in fat than the sifted product.

Oats differ from corn in having noticeably more ash, rather more protein and decidedly more fiber.

THE DIGESTIBILITY OF OATS.

The coefficients of digestibility were not determined in the particular sample fed. Here follow the average coefficients obtained for American and German oats: —

	American.[1]	Foreign.[2]	Corn Meal for Comparison.
Dry matter,	70	70	88
Ash,	25	–	67
Protein,	77	76	–
Fiber,	31	26	–
Extract matter,	77	76	92
Fat,	89	80	90

[1] Lindsey. [2] Kellner.

Applying the above coefficients to the average composition of American and foreign oats, and to the average analysis for corn meal, we have the following amounts of digestible matter in 100 pounds: —

	American Oats.	Foreign Oats.	American Corn Meal.
Protein,	8.78	7.83	6.57
Fiber,	3.35	2.68	-
Fat,	4.27	3.84	3.51
Extract matter,	45.74	44.23	66.24
Total,	62.14	58.58	76.32

One hundred pounds of corn contains, therefore, some 16 pounds, or 27 per cent., more digestible material than a like amount of oats.

Kellner placed the net energy value of corn at 81.5 and of oats at 59.7, or as 100 is to 73.2 (starch equivalents). One would, therefore, assume that for the ordinary purposes of nutrition oats were substantially one-fourth less valuable than corn. This does not take into account the favorable mechanical or special energy effects of oats. The nutritive inferiority of oats is due to the large percentage of indigestible hull. The oat kernel free from hull is easily and highly digestible.

Feeding Experiments for Milk Production.

Three feeding experiments with four cows each were made at this Station. Each animal received a basal ration of hay and bran to which was added an average of 4.5 pounds of corn or oats.. A complete summary of the details of the experiment are given in Part I. of our report for 1912.

It may be said in general that the oat ration gave substantially as good results (*a*) on the weight of the animal, (*b*) on the amount of milk and butter-fat produced, and (*c*) on the composition of the milk.

On the basis of such experiments one would conclude that oats were as desirable as corn for this purpose, which would be contrary to the teachings of analysis and digestion tests. It is believed, however, that the experiments were incorrectly made in that too much of the basal ration was fed, so that when the oats or corn were added the total nutrients were fully up to or in excess of the requirements of the animal. Therefore, the particular effect of the corn or oats was not brought out.

In experiments of this sort care must be taken to keep the basal ration low, so that when the food to be tested is added the total ration shall still be below the animal's average requirement.

The food cost of the milk produced in case of the three experiments was 3.5 per cent. higher for the oat than for the corn ration. If somewhat less of the basal ration had been fed, it is thought that a still greater difference would have been brought out.

In general, it is believed that while oats are a valuable food, it is not economical to feed them for milk production in Massachusetts, and that they are inferior in nutritive value to corn.

SOME PRACTICAL RESULTS OF FEEDING EXPERIMENTS.

J. B. LINDSEY.

Feeding Effect of Raw Potatoes.

In the spring of 1910 potatoes were plentiful and cheap, and some farmers fed them to their dairy animals rather than throw them onto the field. The complaint came to the station that potatoes thus fed caused a noticeable shrinkage in the fat of the milk, and that the cows dried off rapidly. In order to note the validity of such statements three grade Jersey cows were selected that had been in milk since the preceding autumn. They were each given a basal ration of hay, bran and gluten feed, and after an interval of five days potatoes were gradually added and the amount of hay somewhat reduced as the amount of potatoes fed was increased.

Daily Ration in Pounds.

	Betty.				Daisy.				Red III.			
	Hay.	Bran.	Gluten Feed.	Potatoes.	Hay.	Bran.	Gluten Feed.	Potatoes.	Hay.	Bran.	Gluten Feed.	Potatoes.
May 18-22,	18	3	4	–	18	3	4	–	18	3	4	–
May 23-24,	18	3	4	10	18	3	4	10	18	3	4	10
May 25-29,	18	3	4	15	18	3	4	15	18	3	4	15
May 30-June 2,	16	3	4	20	14	3	4	20	16	3	4	20
June 3-5,	16	3	4	25	14	3	4	25	16	3	4	25
June 6-8,	16	3	4	30	14	3	4	30	16	3	4	30
June 9-10,	16	3	4	35	14	3	4	35	16	3	4	35
June 11-15,	16	3	4	40	14	3	4	40	16	3	4	40
June 16-21,	16	3	4	50	14	3	4	50	12	3	4	50

The cows consumed the cut potatoes readily and without any disturbance until they received 50 pounds daily. It was then noted that a little digestive disturbance began to manifest itself, and, the supply of potatoes being limited, the trial was broken off as soon as possible. The potatoes, especially during the latter days of the trial, were of inferior quality and watery. If the amount of hay fed daily had been further reduced, and had the supply of potatoes held out and been of better quality, it is possible that the animals would have consumed more without trouble.

Average Daily Yields of Milk (Pounds).

	Betty.	Daisy.	Red III.
May 18–22,	18.5	18.2	19.2
May 23–June 2,	20.1	20.3	21.4
June 3–10,	19.0	18.9	21.2
June 11–21,	18.4	20.3	22.0

It is evident that the addition of the potatoes in two out of three cases not only checked the natural shrinkage but actually increased the flow.

Composition of Milk.

DATES.	BETTY.			DAISY.			RED III.		
	Total Solids.	Fat.	Solids not Fat.	Total Solids.	Fat.	Solids not Fat.	Total Solids.	Fat.	Solids not Fat.
May 23–26,	13.83	5.10	8.73	14.27	5.75	8.52	15.04	5.35	9.69
June 6–8,	14.71	5.08	9.63	15.68	5.88	9.80	14.36	5.35	9.01
June 9–12,	14.91	5.20	9.71	15.94	6.13	9.81	14.43	5.40	9.03
June 16–19,	14.93	5.35	9.58	15.75	5.90	9.85	14.42	5.35	9.07
June 23–26,	15.43	5.65	9.78	15.69	5.88	9.81	14.59	5.28	9.31

In two out of three cases one notes an increase in the milk fat, due, presumably, to an advanced stage of lactation. In case of Red III. the milk fat remained constant throughout the entire trial. It would appear that the potatoes increased the percentage of solids not fat in the milk produced by Betty and Daisy. The results in case of Red III. are just the opposite, the percentage of solids not fat showing a noticeable decrease. One does not feel justified, therefore, in drawing any positive conclusions other than to state that the chemical composition of the milk was not in any way adversely affected. Unfortunately, observations upon the flavor of the milk were not made.

Conclusions and Observations.

1. When potatoes are cut and fed in amounts up to 25 pounds per head daily, they in no way affect the health of the animal or the yield or quality of the milk.

2. The feeding should begin gradually, and when the supply begins to get low the amount should also be decreased gradually. They should always be fed with reasonable amounts of grain and hay; one of the concentrates should be fairly rich in fat. If fed in too large amounts at first, or in excessive amounts, or without the necessary amounts of other feedstuffs, they are likely to cause diarrhœa, colic and bloating. Such conditions naturally disturb the entire equilibrium of the animal and result in loss of flesh, decreased milk yield and a generally debilitated condition. They should not be fed with malt sprouts or molasses, and with only limited amounts of silage.

Results of Foreign Observations.

Kellner[1] writes concerning the German experience in feeding raw potatoes, from which the following is a résumé: —

An opinion has been handed down from earlier times, and still more or less prevails, that raw potatoes cause inflammation of the stomach and intestines, resulting frequently in digestive disturbances such as diarrhœa, bloating, colic, and, in case of young animals, lameness. Such disturbances he attributes to the fact that exceptionally large amounts of potatoes were fed — up to 100 pounds or more daily — without the addition of sufficient amounts of other feedstuffs. The fact must not be lost sight of that different animals are differently affected by raw potatoes. The most sensitive is the horse, then follows the sheep, while the steer and cow are able to consume them with less trouble.

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[1] Die Ernährung d. Landw. Nützthiere, fünfte Auflage, pp. 327–329.

Fattening steers can take as high as 60 pounds of raw potatoes daily per 1,000 pounds of live weight. Small amounts should be given at first, followed by a gradual increase, together with 2 to 3 pounds of linseed meal or other feedstuffs fairly rich in fat, in addition to some other grain and hay or straw. If it is desired to cease feeding the potatoes this also should be done gradually. Potatoes may also be mixed and fed with other roots, especially mangolds.

Working oxen should not be given more than 20 pounds daily per 1,000 pounds of live weight, preferably mixed with cut hay or straw, in addition to their grain ration.

Milch cows should not, as a rule, receive over 25 pounds daily per 1,000 pounds live weight, together with some concentrate rich in oil. Kellner states that larger amounts are likely to produce a thinner milk possessing an unpleasant taste, the latter lasting for some time after the removal of the potatoes. Churning is likely to be long delayed when milk is used from cows fed with large amounts of potatoes.

Dry cows to be fattened, on the other hand, can be given as high as 40 pounds of potatoes daily, in addition to the feedstuffs above named.

It is not advisable to feed potatoes to *yearlings* and *heifers with first calf,* although from 10 to 15 pounds daily may be given *steers* the second year.

Sheep may be fed with 2 to 3 pounds daily per 100 pounds live weight.

Horses that are obliged to work hard and to move fast should not receive over 2 to 3 pounds of potatoes daily per head, although slow-working farm horses and three to four year old colts in foal may take as high as 12 pounds daily without trouble, in place of one-third of their grain ration. One must use good judgment and be very careful in feeding potatoes to horses, otherwise troubles such as diarrhœa and colic are very likely to result. In all cases where potatoes are fed it is important that they be of good quality, that they have not sprouted, and that they be cut and fed mixed with an equal amount of cut hay or straw and some salt.

MOLASSES FOR FARM STOCK.

Residuum molasses from the sugar beet factories is largely used in Europe as a food for farm stock. It is fed either diluted with water as a drink or mixed by the feeder with a variety of substances to absorb it, such as finely cut hay and straw, brewers' dried grains, malt sprouts, wheat bran, cocoanut cake, dried beet and potato residues.

In New England cane molasses is brought in tank steamers from Porto Rico, and the grades unsuited for human consumption are freely offered at about 16 cents a gallon of 12 pounds, in barrel lots. Beet molasses is also sold, usually mixed with beet pulp, or as a component of proprietary mixtures.

Composition of Molasses.

The composition of cane molasses used as a cattle food is substantially as follows: —

	Per Cent.
Water,	24–28
Ash,	6–7
Crude protein,	2–3
Sugars (cane, dextrose and fruit),	55–58
Gummy or uncrystallized carbohydrates,	7–10

Molasses, therefore, consists of about one-fourth water and the larger part of the balance of sugars and allied substances. The crude protein is a negligible quantity, while fiber and fat are not present.

Beet molasses contains more crude protein than cane molasses, but it is in a form that renders it of little value as a flesh former.

Molasses has the same type of composition as corn meal, both being low in protein and very high in carbohydrates. The dry material of molasses differs chemically from corn meal in containing even less protein with an inferior nutritive value, more ash, and in having its carbohydrates in the form of sugars rather than starch.

Digestibility of Molasses.

It can be assumed with safety that molasses, being soluble in water, is easily digested and assimilated when fed in reasonable amounts. If fed in excess it is likely to affect adversely the heart and kidneys and to appear undigested in the urine.

Effect of Molasses on Digestibility.

As a result of numerous experiments it may be stated (*a*) that while molasses is completely digested, it does not improve the digestibility of the feedstuffs with which it is fed, but actually causes them to be less digestible (the average being 8 per cent.), and (*b*) that the addition of molasses to a ration slightly lessens the digestibility of the *entire mixture*. Only when 20 per cent. or more of molasses is added to a ration is the digestibility of the mixture slightly increased above the digestibility of the same ration fed without molasses. It is not advisable, as a rule, to feed a ration containing over 15 per cent. of molasses, so that under ordinary feeding conditions it may be stated that a total ration containing that amount of molasses would not have a higher digestibility than if fed without it, for the reason that the complete digestibility of the molasses itself is offset by the digestion depression which it exerts on the other feedstuffs.

Relative Value and Use of Molasses.

It must not be understood that because molasses lessens the digestibility of the other feedstuffs, or does not improve the digestibility of the mixture of which it is a component, that it has no feeding value. In fact, 2,000 pounds of molasses have substantially three-fourths of the nutritive value of corn meal, and if corn meal retails at $30 a ton, from the standpoint of nutrition, one can afford to pay $22.50 for a ton of molasses. Aside from its nutritive effect it possesses other desirable qualities to which allusion will presently be made.

Molasses for Dairy Animals. — Three to 5 pounds of molasses may be fed to cows daily in place of a like amount of corn meal, either in water as a drink or partly diluted with water and sprinkled over the hay or cut corn stover, or mixed with the protein concentrates. The writer, however, does not see any advantage to be gained by northern farmers from the use of molasses as a food for dairy stock in place of corn meal and similar carbohydrates. As an appetizer for cows out of condition and for facilitating the disposal of unpalatable and inferior roughage and grain, 2 to 3 pounds of molasses daily undoubtedly would prove helpful and economical.

For fattening Cattle. — Some 3 pounds daily of molasses may be fed advantageously, especially during the finishing process when the appetite is likely to prove fickle. The object at such a time should be to make the food especially palatable and thus induce a maximum consumption, and also to secure a bright, sleek appearance.

For Horses. — French and German investigators have studied and recommended the use of moderate amounts of molasses for horses. It is recommended as a condiment to be mixed with otherwise unpalatable foods, for its influence in improving the appetite and digestion of horses out of condition, and likewise for its favorable effect in case of colic. The writer of this article is not inclined to recommend the indiscriminate use of molasses in place of cereals and their by-products. As an appetizer and tonic for horses out of condition, as a colic preventive, and for improving the palatability of rations, 2 to 3 pounds daily undoubtedly will prove productive of satisfactory results. To facilitate the mixing with grains or roughage it is best to warm the molasses and then add a little warm water to dilute it.

For Pigs. — Favorable reports are made in the German literature relative to the use of molasses for pigs. At this college satisfactory results were secured at one time by stirring 50 pounds of low-grade flour into a barrel full of water, steaming the mixture for an hour or more and then adding a gallon of molasses. The writer, as a rule, sees no particular advantage, under ordinary conditions, for the northern farmer to employ molasses in pig feeding other than as an appetizer.

Molasses Feeds.

Molasses feeds usually consist of cereal grains or their by-products, such as oat clippings, oat and barley hulls, ground grain screenings, flax shives, ground alfalfa hay, one or more protein concentrates (usually cottonseed meal or gluten feed) and one-fourth to one-third molasses. The molasses is used for the threefold purpose of disguising the inferior feedstuffs, for improving the palatability of the mixture, and as a direct source of nutrition. The grain hulls, screenings, and the flax shives are used because they are relatively cheap, and also to serve as an absorbent for the molasses. The cereals themselves, at times, are of an inferior character, being imperfectly developed or moldy. The cottonseed meal and gluten feed are used to increase the protein content of the feed. Flax shives consist of the ground stalks and pods of the flax plant, and have a decidedly inferior feeding value. The better class of grain screenings possess considerable nutritive value. A number of years since, the writer studied the nutritive value of molasses feeds and found them to be moderately digestible (69 per cent., as against 62 for wheat bran, 79 for cottonseed meal and 88 for gluten feed and corn meal). During the last few years it is believed that the general character of these feeds has somewhat improved, in that the grain screenings have been ground, the protein content of some of them materially increased, and the fiber percentage lessened, all of which would tend to increase their digestibility. One notes at present, extremes of from 16 to 25 per cent. of protein and from 8 to 16 per cent. of fiber. A molasses feed that contains 18 per cent. of protein, and not over 9 per cent. of fiber, is worthy of consideration by feeders, providing it can be bought at a reasonable price. The tendency has been for the manufacturers to give them attractive names, make exaggerated claims for them and to sell them at prices in excess of their value. It is believed that local dealers secured a greater margin of profit on such mixtures than on staple feed articles.

It is not intended to discourage the utilization of low-grade by-products; when, however, they are disguised and sold at substantially the same prices as high-grade feeds, attention should be sharply called to the fact.

This autumn (1912) molasses dairy feeds retailed at from $27 to $34, and the horse feeds at from $34 to $40 a ton. It is believed that the average feeder can do better by purchasing staple grains and standard by-products and mixing his own ration. Advice concerning special brands cannot be given in this article. The feeder must study the guarantees and cost of the feed mixtures and use his best judgment, or seek the advice of the experiment station.

THE FOOD VALUE OF PLAIN AND MOLASSES BEET PULP.

A few years ago[1] the writer published a brief review of the value of beet residues for farm stock. Since this publication two experiments have been made at this station, comparing both the plain and molasses pulp (dried) with corn meal for milk production.

Beet pulp is the residue from the manufacture of sugar from sugar beets. The dried plain pulp is coarse and of a gray color. Molasses beet pulp is the pressed plain pulp mixed with the residuum beet molasses and dried. Another method of making the molasses pulp is to mix a definite amount of molasses with the dried pulp. It is understood that but little molasses pulp is now being made.

Composition of the Beet Pulp.

	Plain Pulp.	Molasses Pulp.	Corn Meal[2] for Comparison.	
Water,	9.08	8.48	14.99	15.60
Ash,	3.02	6.93	.86	.85
Protein,	8.90	11.16	7.88	7.82
Fiber,	18.76	10.16	.81	.80
Extract matter,	60.59	62.76	69.76	69.27
Fat,	.65	.51	5.70	5.66
Total,	100.00	100.00	100.00	100.00

It will be noted that the plain pulp contained about 9 per cent. of water, a relatively large amount of fiber, and practically no fat. The molasses pulp contained considerably more ash, due to the large amount of mineral matter in the molasses. The fiber content was considerably less than that of the plain pulp, due to the replacing of the pulp by the molasses which was without fiber. The amount of molasses added to the pulp appears to vary more or less in different samples.

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[1] Twenty-second report of this station, Part II., pp. 21–27.

[2] Samples used in experiment.

Both the plain and the molasses pulp are carbohydrate feeds similar to corn meal, being relatively low in protein and high in carbohydrates.

Pounds of Digestible Matter in a Ton.

	Protein.	Fiber.	Extract Matter.	Fat.	Totals.
Plain pulp,	92.56	311.42	1,005.79	-	1,409.77
Molasses pulp,	140.62	162.56	1,129.68	-	1,432.86
Corn meal for comparison,	105.59	-	1,283.58	101.88	1,491.05

The above figures show that a ton of the corn meal with substantially 15 per cent. of water contains about 5 per cent. more digestible organic nutrients than a ton of the dried beet pulp having 9 per cent. of water. One would not, therefore, expect to note much difference in the effect of these several feeds when used as a component of grain rations intended for milk production.

Practical Feeding Trials.

Six cows were fed on a basal ration of hay, bran and cottonseed meal. In addition, three of the cows averaged 4.3 pounds of dried plain or molasses beet pulp, while the other three were receiving a like amount of corn meal. After a lapse of five weeks the conditions were reversed. The results may be briefly stated as follows: —

Milk Yields (Pounds).

CHARACTER OF RATION.	Total Milk.	Daily, per Cow.	Total Fat.	Butter Equivalent.
Corn meal,	3,941.3	18.8	215.3	251.1
Plain beet pulp,	4,017.1	19.1	216.5	252.6
Corn meal,	4,184.0	19.9	233.4	272.3
Molasses pulp,	4,054.0	19.3	220.6	257.3

In the first trial the corn meal ration produced about 2 per cent. less milk than the plain pulp ration, and in the second trial the corn meal ration caused an increase of some 3 per cent. of milk over the molasses pulp ration. These results are evidently within the limit of a reasonable experimental error, and one can conclude that the corn meal and beet pulp as components of a ration had about the same effect.

If the pulp can be purchased at a cheaper price per ton than the corn, it would prove a little more economical for dairy animals. If fed in an amount exceeding 3 pounds per day, it should be moistened with two to three times its weight of water.

The Place of Dried Beet Residues in Farm Economy.

Farmers who are in position to produce their own feed cannot afford, as a rule, to purchase starchy feedstuffs; they should be produced upon the farm in the form of corn, oats and barley. For milk production it is much more desirable to purchase materials rich in protein, such as cottonseed and linseed meals, dried distillers' and brewers' grains, gluten feed, malt sprouts, fine middlings and even bran. These feedstuffs are not only very helpful in milk production, but likewise supply large amounts of nitrogen in the resulting manure. When the supply of home-grown corn is exhausted or limited, beet residues may be substituted for fattening stock and as one-third of the grain ration for dairy purposes. Milk producers who purchase all of their grain will find the dried pulp a satisfactory component (one-third to one-half) of the daily grain ration. It can also be fed as a partial substitute for roughage in amounts of from 8 to 10 pounds of dry pulp daily. It should be mixed with two to three times its weight of water.

EFFECT OF FROST ON CORN.

J. B. LINDSEY.

So far as known, accurate data on this subject are not available. On Sept. 1, 1911, a severe frost occurred in New England, and most of the corn was severely frosted. At the experiment station the frosted corn was allowed to stand uncut for some two weeks, at which time samples of the different varieties were brought to the laboratory for examination. The ordinary analysis revealed little new, excepting that the fiber percentage seemed to be larger than is usually the case. It is doubtful if a more thorough chemical inquiry would give any definite information, for the reason that so many factors enter into the problem, such as variety, stage of growth and time of frosting. In order to get the necessary data, the following conditions would be necessary: (*a*) samples of corn secured within a day or two before frosting; (*b*) samples immediately after frosting; (*c*) if frosting occurs at this station between September 1 and 5, samples also to be secured of both frosted and unfrosted corn some two to three weeks after frosting, time of cutting to be the same in each case. By such a method one would be able to get comparative data. The mere taking of a sample after frosting is not likely to prove helpful if unfrosted samples at a similar stage of growth were not available for comparison.

WHAT PROBABLY OCCURS.

It seems probable that something like the following happens when corn is badly frosted: —

1. The cells of the plant burst, discharging the cell contents, and further growth ceases. This first evidently affects the leaves, husks and upper part of the stalk. It is doubtful if the ears and inner portion of the larger part of the stalk are touched.

2. The more immature the crop the more the damage and *vice versa,* because (*a*) frosting checks further development and (*b*) the plant, being in an immature state, is more easily decomposed by micro-organisms.

3. The contents of the ruptured cells fall an easy prey to bacteria, are decomposed, and their food value lessened or destroyed. It is doubtful if the organic matter already completely formed, such as fiber, starch and protein, is attacked. It is the material in *process of formation* that suffers deterioration.

4. The rupture of the cells causes the water content of the more tender portions of the plant to dry out rapidly, and these parts become brittle, break off and are lost.

How to handle Frosted Corn.

It would appear, therefore, that the losses are threefold: (*a*) further growth checked; hence, the earlier the frost, the more serious the loss; (*b*) chemical; (*c*) mechanical.

In case the corn is intended for the silo, the quicker the crop is ensiled the better. If the crop is not to be ensiled, it may be allowed to stand uncut for a week or two. It should be cut and stacked between September 20 and October 1. The extent of the injury, expressed in figures, is difficult to state. The greatest loss is evidently due to the checking of further growth, and the second greatest is probably mechanical, due to rapid drying and falling away of the leaves and external portions of the stalk. Palatability may be somewhat lessened. These combined losses are not as serious as are often imagined, the plant still retaining the larger part of its feeding value.

BEET SUGAR IN NEW ENGLAND.

J. B. LINDSEY.

The Massachusetts Agricultural College investigated the subject of sugar beet production in this State as early as 1870. In its eighth report for 1871 the late Professor Goessmann published a comprehensive review of the sugar industry — beet, sorghum and cane — both at home and abroad. A large amount of valuable data is therein collated.

In the report for 1872 he gave the results of experiments conducted upon the college farm and elsewhere and drew the following conclusions: —

1. It is possible to grow beets of high sugar content in Massachusetts upon well-drained mellow loams when proper attention is given to fertilization and cultivation.

2. Whether or not the industry will prove profitable in Massachusetts depends upon the area that is available for the cultivation of the beet, and whether the necessary capital can be secured to erect sugar factories for the extraction of the sugar.

Later, considerable beets were grown in the vicinity of Franklin, Mass., and a small factory erected for the manufacture of the sugar. This enterprise did not meet with success, owing, among other things, to the crude methods employed in the factory and the relatively small supply of beets available. The industry has languished since that time in this State, although it has thrived particularly in California and Michigan.

In order to make the industry a success large tracts of comparatively level land must be available, and the factory must be located as near the center of the area as possible. It is doubtful if the hill towns of the State would be suited to the conditions, the beets having to be transported to the factory either by rail or wagon. It is believed by the writer that the land in other portions of the State — the Connecticut valley, Worcester County, etc. — is more valuable for the production of other crops, such as tobacco, onions and vegetables, than it could be for the production of sugar beets. Brooks, in his book entitled "Agriculture," states his opinion as follows: —

> The production of sugar beets is hardly likely, in the opinion of the writer, to prove profitable in the New England States. In that section greater profits can be derived from the cultivation of numerous other crops to which the soil and climate are suited and which can be readily disposed of in the markets of that section of the country.

It is not true that beets improve the fertility of the land. Sugar beets thrive best in deep, rich mellow loams. Well-rotted stable manure, green crops plowed in, supplemented with phosphates and high-grade sulfate of potash, preferably applied in the autumn, are the most suitable fertilizers. It would be useless to try to grow sugar beets on shallow, unfertile soils. The writer is, therefore, of the opinion that while the climate is satisfactory and a considerable area is suited to the beet, economic conditions are not favorable to the production of beet sugar in Massachusetts.

MALNUTRITION OR OVERFERTILIZATION OF GREENHOUSE CROPS.

H. D. HASKINS.

Crops grown in greenhouses under somewhat artificial conditions are likely to suffer from a variety of troubles. In this paper data will be presented which strongly indicate that imperfect growth and development are due in many cases to an accumulation of soluble plant food rather than to fungi and bacteria.

Condition of Diseased Cucumber Crop.

The pathological description of the affected crop is briefly as follows: —

The plants, which at first are usually very vigorous, turn yellow prematurely and fail to develop fruit. The leaves become more or less spotted, resembling the mosaic troubles sometimes seen on other plants. When studied with the microscope no fungous disease is apparent. The trouble does not usually develop until the third year after the soil has been placed in the houses, and its appearance seems to depend wholly upon the manner in which the soil has been prepared and managed.

Method of preparing the Soil. — In those cases where the trouble has been experienced the third year, the preparation of the soil has consisted in mixing equal amounts of pasture sod and horse manure and allowing it to remain a couple of months before transferring it to the houses. Upon placing the soil in the houses more manure and also some lime were added, and when the cucumber plants were set a trench of horse manure and chopped straw was used beneath to furnish underground heat. During the growth of the crop a considerable quantity of nitrate of soda and chemical fertilizer was supplied. This treatment must necessarily result in a very rich soil which produces a heavy crop the first year.

The treatment of the soil the second year consisted in spading in a heavy layer of horse manure and in working into the soil the available portion of the manure which was used in the trenches for heat the previous year. Trenching with manure for underground heat was again resorted to, and the nitrate of soda and chemical fertilizers were used as in the previous year. This general treatment is followed for each successive crop until the result is a crop failure.

Chemical Analysis of Such Soils. — In the following table is given a chemical analysis of a soil which had served for three successive years in a greenhouse for cucumbers. In order that any one unfamiliar with the interpretation of soil analyses may understand the extent to which the plant food has accumulated, the average analysis of 38 samples of barnyard manure is given for comparison.

	Analysis of Cucumber Soil.	Analysis of Barnyard Manure, Average of 38 Samples.
Moisture,	36.72	73.38
Organic matter,	9.92	-
Nitrogen,	.55	.42
Potash,	.48	.53
Phosphoric acid,	.51	.31
Calcium oxide,	1.12	-
Sodium oxide,	.43	-
Magnesium oxide,	.47	-

The above results show the cucumber soil to be considerably richer in nitrogen and phosphoric acid than are the better grades of mixed farm manures. Although this large amount of *total* plant food in the soil may be an *indication* that the soil is too fertile, yet it is probable that the injurious effect is due to the soluble or active portion of the constituents present.

Composition of Normal and Abnormal Soils. — Occasion is here taken to bring together some results of analyses of abnormal and normal cucumber soils. The abnormal soils were all sent at various times by parties having trouble with their crops, in some cases resulting in failure. The normal soils giving excellent results were procured by the writer from well-known growers in various localities in Massachusetts.

The laboratory method of examining the soil consisted in leaching 400 grams with 1,000 cubic centimeters of hot water; the resulting solution was evaporated to dryness on a water bath and a chemical analysis made of the residue. The results in Table No. 1 have been computed to parts in 100 parts of dry soil for the sake of comparison.

Table No. 1. — *Showing Per Cent. of Water Soluble Constituents in 100 Parts of Dry Soil.*

	Abnormal Soils.					Normal Soils.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	A.	B.	C.
Total water soluble salines,	1.840	1.680	1.136	.5402	.50430	.456	.2940	.190
Soluble nitrogen,	.050	.012	.102	.0532	.02332	.025	.0055	.025
Soluble potash,	.500	.410	.238	.1123	.14360	.085	.0550	.026
Soluble phosphoric acid,	.040	.045	.020	.0201	.00630	.017	.0007	.002
Soluble calcium oxide,	.064	.045	.057	.0359	–	.047	.0310	.030
Soluble sodium oxide,	.220	.210	.192	.0236	.03200	.068	.0600	.075
Soluble magnesium oxide,	.054	.036	.031	–	–	.022	.0090	.009
Soluble sulfates (SO_3),	.069	.036	.050	–	–	.049	.0290	.008

In this table should be noted the large amount of total and single soluble mineral constituents in the abnormal as compared with those in the normal soils. A number of interesting facts are brought out in the analytical results. Note, for example, the large amount of water soluble potash as compared with the total potash content of the soils. In case of soil No. 3, the total potash was .76 per cent., of which .24 per cent. was found present in water soluble form. The amount of phosphoric acid present in the water solution of the soil is quite exceptional. The writer has never found but two samples of out-of-door soil which showed more than mere traces of phosphoric acid in water soluble form, and these two samples were tobacco soils showing strong indications of overfertilization. The presence of a comparatively large amount of soluble nitrogen was to be expected.

To bring out in a more striking manner the differences in the two types of soil, the results have been computed in Tables Nos. 2 and 3, on the basis of pounds of the various constituents per acre of soil containing 20 per cent. moisture.[1]

TABLE NO. 2. — *Showing the Average Composition of the Abnormal as compared with the Normal Soils.*

	POUNDS PER ACRE	
	Abnormal Soils. Average of Five Analyses.	Normal Soils. Average of Three Analyses.
Total water soluble salines,	27,363	7,520
Soluble nitrogen,	1,156	444
Soluble potash,	6,743	1,328
Soluble phosphoric acid,	632	208
Soluble calcium oxide,	1,211	864
Soluble sodium oxide,	3,259	1,624
Soluble magnesium oxide,	966	320
Soluble sulfates (SO_3),	1,240	727

This table shows a marked increase of soluble plant food in the abnormal soils. To express this amount of plant food in terms of fertilizers, a calculation shows that to furnish the nitrogen would require 3¾ tons of nitrate of soda; to furnish the potash, 6¾ tons of high-grade sulfate of potash; to furnish the phosphoric acid, 2 tons of 16 per cent. acid phosphate; and to furnish the lime, 1 ton of hydrated lime. To express the results in terms of a mixed fertilizer made up of the highest grades of material it would require an application of 14½ tons of a formula testing 4 per cent. nitrogen, 23 per cent. actual potash and 2.25 per cent. available phosphoric acid. It should be understood that the results given in the above table represent only that portion of the plant food which is *soluble in water.*

In Table No. 3 is shown the variation in composition of the different samples in both types of soil.

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[1] Assuming that an acre of soil 1 foot in depth weighs 3,000,000 pounds.

TABLE NO. 3. — *Showing the Pounds of Water Soluble Constituents in an Acre of the Different Soils with Average Moisture Conditions (20 Per Cent.).*

	ABNORMAL SOILS.					NORMAL SOILS.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	A.	B.	C.
Total water soluble salines,	44,160	40,329	27,300	12,965	12,063	10,944	7,056	4,560
Soluble nitrogen, . .	1,200	288	2,457	1,277	558	600	132	600
Soluble potash, . . .	12,000	9,840	5,733	2,695	3,446	2,040	1,320	624
Soluble phosphoric acid, .	960	1,080	491	482	150	408	168	48
Soluble calcium oxide, .	1,536	1,080	1,365	862	–	1,128	744	720
Soluble sodium oxide, .	5,280	5,040	4,641	566	768	1,632	1,440	1,800
Soluble magnesium oxide,	1,296	864	737	–	–	528	216	216
Soluble sulfates (SO_3), .	1,656	864	1,201	–	–	1,296	696	192

All of the abnormal soils are shown to contain more water soluble salines than do the normal soils, although in two instances the difference is not marked. The amount of the various constituents which make up the total soluble salines differs widely in the several samples, the range being fully as great in the normal as in the abnormal soils. The amount of potash and magnesia is greater in all of the abnormal than in the normal soils. The other constituents — nitrogen, phosphoric acid, calcium oxide, sodium oxide and soluble sulfates — are present in larger quantities in some of the normal soils than in the abnormal, although this is not true when the averages are compared, as has been shown in Table No. 2.

The wide variation in the amounts of the various soluble constituents, and the fact that some of them are found in larger amounts in the normal than in the abnormal soils, would indicate that the injury was not due to the toxic effect of any one constituent, but rather to the combined effect of the total soluble mineral matter.

A further study of Table No. 3 would indicate that the safe limit of concentration of the soluble ingredients is around .5 per cent. on the basis of 100 parts of dry soil, or 12,000 pounds per acre foot with normal moisture. On this basis it could be assumed that sample A, which is listed in the table as a normal soil, was very near the danger mark, and no doubt it would be good judgment to remove one-third of this soil and replace with new before putting in another crop. That it is not necessary to have such an excessive amount of soluble plant food present in order to grow satisfactory crops is proved by a reference to sample C, listed under normal soils, which had been used for three seasons with very satisfactory results. Note the comparatively small amount of total and individual soluble salines present.

In case of this latter soil, about one-half of the organic matter was derived from air-dried peat. The abundance of organic matter present insured suitable mechanical conditions as well as the conservation of moisture. The writer is of the opinion that a good quality of well-cured, air-dried peat, or even waste from cotton mills, might be used to good advantage when preparing the soil, in place of one-half of the horse manure which is generally used. The use of peat would, of course, necessitate an abundant application of lime (about 5 bushels per cord of peat), and the soil should be mixed several months before being placed in the houses, and should be worked over at least twice during that time.

The above inquiry has been confined to the cucumber crop, but almost any plant may suffer from overfertilization. It may be stated that the various plant families differ in their ability to withstand the effect of concentrated soil solutions. The growth of young tobacco plants has been checked and the plants seriously injured by about one-eighth as much water soluble salines as were shown to be contained in the average abnormal cucumber soil.[1]

Effect of Overfertilization on Sweet Peas.

Some of the crops grown by florists often suffer from the effect of malnutrition. In 1911 four samples of soil upon which sweet peas had been growing were forwarded to the station for examination. Two of the samples were from houses showing a satisfactory normal growth, and two were from houses where the plants were unproductive and were suffering badly from some cause. Dr. Stone, the plant pathologist, examined specimens of the plants under the microscope, but failed to find them suffering from any disease caused by bacteria, and suggested a chemical examination of the soil.

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[1] See article entitled, "Tobacco Injury due to Malnutrition or Overfertilization," in Part II of the twenty-fourth annual report of this station, pp. 35-47.

The soils were washed out with hot water, and after the water solution had been evaporated to dryness an analysis was made of the residue. The average results have been figured to 100 parts of dry matter for the sake of comparison.

	Average Analysis of Two Normal Soils.	Average Analysis of Two Affected Soils.
Total water soluble salines,	.5364	.6331
Soluble nitrogen,	.0087	.0039
Soluble potash,	.1013	.1232
Soluble phosphoric acid,	trace	trace
Soluble calcium oxide (lime),	.0241	.0274
Soluble magnesium oxide,	.0154	.0185
Soluble sodium oxide,	.0405	.0801

In the following table the above results have been calculated so as to express the amount of constituents present in pounds per acre foot with normal soil moisture (20 per cent.): —

	Pounds per Acre.	
	Average of Two Normal Soils.	Average of Two Affected Soils.
Total water soluble salines,	12,874	15,193
Soluble nitrogen,	209	91
Soluble potash,	2,433	2,957
Soluble phosphoric acid,	traces	traces
Soluble calcium oxide (lime),	580	657
Soluble magnesium oxide,	369	445
Soluble sodium oxide,	972	1,923

These figures show the affected soil to contain a considerably larger amount of total soluble salines and, with the exception of nitrogen, a larger amount of the individual soluble mineral constituents than do the normal sweet-pea soils. Even the normal soils show a very liberal amount of water soluble plant food.

The normal soils showed the presence of .46 per cent. of total nitrogen, and the affected soils .66 per cent., mostly in organic form. The appearance of the soils indicated that a large amount of horse manure had been used in their preparation.

Soils to be used for sweet-pea culture should not have an excessive amount of available nitrogen present, as it produces a large watery growth of stem and leaf which results in weakening the plant and is unfavorable to blooming. The soils examined were noticeably acid, a condition undesirable for this crop.

Discussion and Suggestions.

The results of our observation on all of the above greenhouse soils suggest that there is a serious fault in the construction of the beds and benches in many cases. Good drainage should always be provided, and, in fact, is more important in the greenhouse than in the open. The soil in the former case is made much more fertile and does not have the benefit of occasional heavy rains to cause leaching, as in the case of the out-of-door soil. In the field there is always a free movement of soil water after each heavy rain, and analyses show the drainage water to contain an appreciable amount of the various mineral constituents. In fact, large quantities of soluble residual salines are thus removed from the soil each year.

A sufficient amount of all the elements of plant food in suitable and available forms should, of course, be supplied, and a certain excess is even essential in order that the crop may make a quick growth and be ready for the early market. Too great an excess of horse manure should be avoided, however, and chemical plant food should be used with the same care and judgment that would be used when applying them to crops grown in the open field. If 500 pounds of high-grade sulfate of potash are considered the maximum amount to be applied per acre (4,840 square yards), then 1.6 ounces would be the maximum amount to apply per square yard in the greenhouse. In other words, a calculation can easily be made for the application of all fertilizing materials in the greenhouse, and if this were always done instead of relying upon guesswork, cases of overfertilization would not be so frequent, and just as satisfactory crops would be grown.

To give an approximate idea of the total amount of plant food, as well as the available plant food furnished by horse manure when mixed with the soil in various proportions for use in the greenhouse, the following table has been prepared: —

	Pounds of Total Plant Food per Acre.			Pounds of Plant Food likely to be available the First Season.		
	A.	B.	C.	A.	B.	C.
Nitrogen,	5,800	3,863	2,900	2,320	1,545	1,160
Phosphoric acid,	2,800	1,850	1,400	2,380	1,585	1,190
Potash,	5,300	3,530	2,650	3,971	2,648	1,985

"A" represents one-half manure and one-half soil; "B," one-third manure and two-thirds soil; "C," one-fourth manure and three-fourths soil.

Wherever indications of overfertilization appear, the soil should be leached out with hot water as soon as the crop is removed. In fact, it is believed that a thorough leaching of greenhouse soil at least once each year would be very beneficial in removing excessive residual salines. The leaching may sometimes be accomplished with water from which the chill has been removed while the crop is still in the ground. Good drainage should always be provided whenever this is undertaken. If the conditions are not favorable for leaching, in case of the cucumber crop, about 3 inches of fresh loam should be applied to the surface of the bed and worked in lightly around the plants. This promotes the formation of new roots and has been known to save the crop.

After the removal of the crop, from one-third to one-half of the soil in the benches should be replaced with new loam before replanting. The removed soil as well as the solution resulting from leaching may be used to good advantage as a fertilizer on out-of-door crops, and would probably prove equal to the average farmyard manure.

TOBACCO STALKS AS A FERTILIZER.

H. D. HASKINS.

Many manufacturing industries are to-day supplying valuable by-products which have become recognized sources of available plant food. Thirty years ago some of these by-products were considered of no special value, and were disposed of in the most convenient manner. In more recent years, as the demand for plant food has increased, manufacturers have been led to investigate the fertilizing value of their by-products. The farm, also, has waste products which should be carefully preserved and used in the most approved manner. The residues from different crops may vary widely in value, depending upon the character and habit of the plant as well as upon the nature of the material itself.

Tobacco furnishes perhaps as large a proportion of valuable refuse material as any of the various farm crops grown in Massachusetts. Since tobacco is a heavy feeder as well as a large plant, and as it is cut before the plant has a chance to develop its seeds, one may expect to find a large quantity of the plant food constituents in the stalk. It is also possible that a movement of plant sap takes place from the leaf to the stalk during the curing process.

The following analyses show the composition of tobacco stalks from which the cured leaf has been stripped (usual process of curing), also stalks from which the green leaf has been picked in the so-called "priming" system of harvesting the crop.[1] Both analyses have been calculated to the basis of 100 parts of dry matter.

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[1] The wide difference in composition of the two kinds of stalks cannot, perhaps, be wholly attributed to method of harvesting, as they represent two different types of the tobacco plant.

	Tobacco Stalks, stripped. Havana Seed Leaf (Per Cent.).	Tobacco Stalks, Priming System. Tent-grown (Per Cent.).
Nitrogen,	3.25	1.10
Potash,	4.95	1.00
Phosphoric acid,	.78	.26

Only a relatively small amount of tobacco is "primed" at the present time, but this method of harvesting seems to be growing in favor. In either case the stalk has valuable fertilizer properties which, if handled in the right manner, become of considerable importance in maintaining soil fertility.

Statistics tell us that 5,700 acres were devoted to the tobacco crop in Massachusetts for the year 1912. Communication with several of the large tobacco growers brings out the fact that on an average 8,666 Havana seed leaf plants are grown per acre. The average weight of 10 stalks from which the leaf had been stripped was found to be 6.58 pounds,[1] which, computed on an acre basis, would amount to 5,702 pounds. It was found that the water content of the stalks from different localities varied considerably, the average being 52.94 per cent. In other words, 3,018 pounds out of the total weight of stalks per acre were found to be water, and 2,684 pounds, dry matter.

The analysis of two samples of stalks grown by the usual method showed the following chemical composition on a dry-matter basis: —

	Stalks received from Oscar Belden & Sons, Bradstreet, Mass. (Per Cent.).	Stalks received from G. P. Smith, Sunderland, Mass. (Per Cent.).
Phosphoric acid,	.74	.82
Potassium oxide,	5.23	4.67
Total nitrogen,	3.00	3.49
Water soluble organic nitrogen,	2.01	2.52
Active water insoluble organic nitrogen,	.25	.23
Inactive water insoluble organic nitrogen,	.74	.74

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[1] Weights secured in three different sections of the Connecticut valley.

On the basis of the above figures, the stalks on an acre would contain the following amounts of plant food: —

Nitrogen,	87.23
Potash,	132.85
Phosphoric acid,	20.94

Applying the same commercial values that are usually given to the plant food found in cottonseed meal, castor pomace and other organic vegetable substances, the total value of the stalks per acre would be about $24, or about $8.40 per ton of partially dried stalks.[1] If this same valuation is applied to the total product of the State, the commercial value of the plant food found in the tobacco stalks grown in Massachusetts for the year 1912 amounts to $136,800.[2]

The usual method of handling tobacco stalks is as follows: the stalks from which the leaf has been stripped are thrown out upon the land during the fall and allowed to remain until spring, thus permitting the rains and snows to dissolve any valuable fertilizing material which the stalks may contain. They are then placed in small piles, burned and the ashes scattered over the adjoining land. If all of the plant food were washed out of the stalks by leaving them thus exposed, this perhaps would be an economical manner of disposing of the material, but even then there would be the loss of a large amount of organic matter which eventually would have furnished humus.

The matter appeared to be of sufficient importance to warrant a few chemical tests to see to what extent the plant food was removed by the exposure of the stalks upon the land during the fall and winter months. Stalks thus exposed were procured under average conditions and subjected to a chemical analysis with the following results (calculated to a dry-matter basis): —

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[1] By "partially dried" is meant a material containing 50 to 53 per cent. moisture; the green stalks at stripping time may contain from 70 to 75 per cent. moisture.

[2] This valuation is somewhat high for the reason that the labor cost of handling a definite amount of plant food in tobacco stalks would be greater than that of handling the same plant food in cottonseed meal.

	Nitrogen (Per Cent.).	Potash (Per Cent.).	Phosphoric Acid (Per Cent.).
Unexposed stalks,	3.25	4.95	.78
Leached stalks,	1.39	2.44	.70
Amount dissolved,	1.86	2.51	.08

The above data show that the exposed stalks have lost by leaching about 57 per cent. of the total nitrogen and 51 per cent. of the total potash contained in the original stalks. The form in which the nitrogen was present in the unexposed stalk was also determined. Ground, air-dried, unexposed stalks testing 3.29 per cent. nitrogen (3.49 per cent. on a dry-matter basis) were tested for nitrates, albuminoid nitrogen and amid compounds, with results as stated below: —

	Per Cent. in Dry Matter.
Nitrogen as nitrates,	1.29
Nitrogen in form of amid compounds,	1.20
Albuminoid nitrogen,	1.00
Total nitrogen,	3.49

It is quite probable that the leaching process removes most of the nitric nitrogen and a large proportion of the more soluble amid compounds, and that the residual nitrogen found in the exposed stalks is present largely in albuminoid form and is somewhat more slowly available to plants than the soluble portion. The usual practice of burning the stalks would of course result in the loss of this water insoluble nitrogen only, as the potash and phosphoric acid would remain in the plant ash. In the process of burning, an average of about 37.31 pounds of nitrogen (valued at $7) would be lost for every acre of tobacco grown. This would represent a value of $39,900 in Massachusetts, without considering the loss of the organic matter (some 2,000 pounds to the acre).

It is believed that the most economical way for large tobacco growers to handle this material is to cut the partially dried stalks as soon as possible after stripping, by means of an ensilage cutter, into pieces an inch or so in length, spread them broadcast upon the land in late fall and plow them under in the spring. If it seems desirable to allow the uncut stalks to remain on grass land during the winter as a top dressing, they may be gathered in the spring, spread upon land intended for corn and plowed under. The leached stalks will be pretty thoroughly decomposed during the year and will not cause any inconvenience the following season.

INSECT RECORD FOR 1912 IN MASSACHUSETTS.

H. T. FERNALD.

The correspondence received by the experiment station during 1912 was unusual because of its scope, nearly 400 different insects being subjects of inquiry.

As was to be expected, heat and a dry period were favorable for plant-lice of many kinds and for the San José scale, and these pests were much in evidence everywhere, over a hundred separate inquiries being received referring to plant-lice. The elm-leaf beetle was also abundant, and where not cared for by spraying, caused much injury.

Ants in houses and in lawns, cutworms, wireworms, various soft scales, the squash vine borer, asparagus beetles, the spiny elm caterpillar and the gypsy and brown-tail moths were also the subjects of many letters, and these, with the other pests mentioned, formed the bulk of the correspondence.

The birch-leaf skeletonizer, *Bucculatrix canadensisella* Chamb., has attracted little attention this year, and it seems probable that it will not be noticeable another fall. The work of the bronze birch borer, *Agrilus anxius* Gory, has been much in evidence, but while many cut-leaved white birches succumbed to its attacks during the first year or two it was present, some now appear to be more resistant and more or less immune. At one time it seemed as though all of these trees would be destroyed; at present it seems possible that some of them may escape.

Numerous egg clusters of the apple-tree tent caterpillar, *Malacosoma americana* Fab., sent in for identification; inquiries about the apple-twig borer, *Schistoceros hamatus* Fab., the bud moth, *Spilonota ocellana* Schiff., and apple aphids indicate that more careful attention than ever before is being given to the apple trees of the State, and in general a closer examination of our crops, in order to protect them from injury, is evident.

Flies, fleas, roaches, bedbugs and other household pests have required considerable correspondence during the year; and it would seem that whenever anything unusual made its appearance anywhere in the State in insect lines, it aroused sufficient interest to lead to inquiries.

During the latter part of September, 1911, an unusual abundance of cotton-worm moths, *Alabama argillacea* Hbn., was noted, and this was also the case almost everywhere through the northern States. Another, but smaller, flight of these moths took place this year, only a single specimen being captured at Amherst. As, so far as known, this insect feeds only on cotton, its appearance so far from where it normally occurs is always of interest.

One brood of the seventeen-year locust or cicada, *Cicada septendecim* L., due in 1911, has never been reported from Massachusetts though abundant in northwestern Connecticut and eastern New York. During that year specimens were captured in New York only about three miles from the Massachusetts State line. Under these circumstances it is probably safe to consider this brood as also occurring in southwestern Massachusetts, though perhaps in limited numbers.

The discovery in January, 1912, of more than 50 specimens of a lady beetle, *Hippodamia ambigua* Lec., in bunches of celery purchased in the market at Amherst, is of interest, as the beetles are natives of the Pacific coast and the celery came from California. Fortunately, these insects are beneficial, but injurious forms could easily be introduced into Massachusetts in similar ways and add to our already too long list of enemies to fight here.

The juniper scale, *Diaspis carueli* Targ., a European foe of the juniper and arbor vitæ, was found during the year in such abundance on plants imported from abroad as to seriously injure them. This insect has already been found in a number of places in this country, probably in all cases having been received from Europe. A serious attack on valuable hedges of box by the box-leaf miner, *Monarthropalpus buxi* Lab., in some parts of southeastern Massachusetts and in Rhode Island, has also been observed, and studies on this insect and methods for its control have been begun. This insect which has evidently come to this country from Europe has already been reported by Dr. Felt (Journ. Econ. Ent. III., 342, 1910).

The cottonwood leaf beetle, *Lina scripta* Fab., was observed feeding on the leaves of poplars in a nursery at Agawam in the fall of 1910, since which time it has been found elsewhere in the Connecticut valley. This insect is well known farther west, and appears to be spreading eastward. Possibly its presence in Massachusetts has already been recorded, but no such reference has been noticed by the writer.

The chestnut borer, *Leptura zebra* Oliv., has been found in numerous instances working on chestnut trees, as reported last year, and has been so often observed in connection with the chestnut bark disease that the claim has been made that it is often the cause of the death of the tree, and that the disease attacks only trees already weakened by this insect. This view in the light of such evidence as is at hand can hardly be accepted, but there is no doubt that trees weakened by this insect would be even more likely to die from the disease on this account.

The fall army worm, *Laphygma frugiperda* S. and A., has been unusually abundant and destructive this year, particularly in eastern Massachusetts. According to reports received this has also been true in many parts of the country.

White ants or termites, *Termes flavipes* Koll., have been reported as injuring the stems of growing cabbage and corn plants, leaving only the outside of the stem. As no other insects could be found in the stems, while the termites were abundant there, it would seem probable that in this case living tissues had replaced the more usual food of these insects, which is dead or decaying wood.

TESTS OF INSECTICIDES.

H. T. FERNALD.

It has not been the policy of the department of entomology of this station to conduct tests of the different insecticides on the market, the department having no trees under its control upon which to make the tests. In a few cases, however, special reasons have led to a departure from this rule, and the results of a few trials of such materials are given here. No attempt is made to draw final conclusions in any case, those given being only such as the tests themselves indicated. It is recognized that farther trials of these materials in other localities, or perhaps under different climatic conditions, might give different results, but as such are not available only those actually obtained here are recorded.

Entomoid. — Manufactured by Frank M. Hale, Woonsocket, R. I. This material was tested in 1911, and the results are given in the last annual report. Entomoid is claimed to be a combination of lime-sulfur and a miscible oil, and should possess the good qualities of both of these materials. The manufacturer believed that a modification of the formula used in 1911 would be an improvement, and it was this modification which was used in 1912. Several apple, pear and plum trees and currant bushes considerably infested with San José scale were sprayed with it, following directions supplied by the manufacturer to dilute 1 part of the Entomoid with 50 parts of water. On two trees a dilution with 40 parts of water was used instead, in order to determine any possible injury by a stronger solution or possibly a greater effectiveness. The treatment was applied April 17, the day being calm, cloudy and with a temperature of 65° to 70° during the treatment. The material mixed easily with water and sprayed well and was dry within a short time. There was quite a heavy rain that night and also some the next day.

As a whole, the results were less satisfactory than in 1911. Whether this difference was due to the difference in the maker's formula, to the rain following within twelve hours, or to the greater dilution (in 1911 with the old formula it was 1 to 20 and 1 to 30), it is impossible to determine. Many of the scales were certainly killed, but enough were left so that the trees were about in their former condition at least three months earlier than was the case in 1911. It may be that the dilution with the new formula material was greater than should have been the case; but the relative concentration of the two materials was, of course, known to the maker, who should accordingly have been able to advise the proper dilution for the second formula to make it properly compare with the first. No difference in results was noted with the two dilutions used.

It may be said of this material that thus far it seems to have some value as a scalecide, but that farther experimental work by the inventor, followed by more field tests of the materials thus produced, will be needed before any final formula can be established.

Nicine. — Manufactured by the Hood Chemical Company, Chicago. This substance appears to be widely used as an absorbent, deodorant and germicide. It is also claimed that it will prevent the hatching of the eggs of insects and will drive away flies. It is "a success when blown on trees and shrubs in destroying insects and fungus."

A claim made in letters from the company, "that it limits the activities of root parasites of all kinds," led to testing this substance both for the protection of corn from wireworms and of onions from the onion maggot. For the corn two plots about a thousand feet apart were taken, and in each, rows were treated in twos, alternating with two untreated, used as checks. The rows were about three feet apart. The Nicine was poured into the drills in fairly large amounts, was then covered slightly and the corn planted over it.

It was anticipated that the plots would be quite badly infested with wireworms, but unfortunately for the success of the test these proved to be rather scarce, and on this account the experiment can hardly be considered a success. The only conclusions which could safely be drawn from the work were the rather negative ones that this treatment had at least no injurious effect on the plants, and that it did not give absolute protection, as a few hills both in the treated and untreated rows were attacked by wireworms, though too few to give evidence of any value.

The tests of this substance for protection against the onion maggot were limited by the small amount available. Two rows of plants were treated, the Nicine being liberally applied around the bases of the plants when they were about an inch and a half high. At this time no maggots could be found anywhere in the field. The Nicine was evident at the bases of the plants for several weeks, but did not wholly protect the plants from maggots, at least, as a few were attacked. Compared with rows treated by other methods, it did not even afford a high degree of protection, but as maggots were not particularly abundant anywhere in the field, and the crop did not " catch " well, the whole test can hardly be regarded as conclusive.

Soil Fumigant and Insecticide. — Manufactured by the Sherwin-Williams Company, Cleveland, O. This material was to have been tested in 1911, but the shipment was lost and not recovered until too late in the season for use. It was applied in the spring of 1912 to parts of the same corn plots described under Nicine above, and in the same manner, though a little more liberally.

For the same reasons as in the case of Nicine the test can hardly be regarded as proving anything. The corn in the treated rows differed little in growth and product from that in those untreated, and the wireworms proved not to be sufficiently abundant to enable any determination of its value to be possible. Tests of this material in Maine and Minnesota during 1911 have been reported as giving no evidence of its value as a protection from the attacks of insects.

Zinc Arsenite. — Received from the Sherwin-Williams Company, Cleveland, O. The company suggested using this at the rate of 1 pound to 10 gallons of water, " in the absence of sufficient data of a practical nature and based only on its chemical composition," and this suggestion was followed.

The material was applied quite freely to elm, maple and wild cherry leaves, July 8, no fruit trees being available for the purpose. Elm-leaf beetle larvæ were abundant on the elm, but the application to the other plants was entirely to determine the danger of injury to the foliage.

In all cases the sprayed leaves were conspicuous until the leaves turned in the fall, indicating an excellent adhesive property. On the elm the beetle larvæ were quickly killed, and after a short time injury to the leaf tissue around each place where a beetle had fed became evident.

After two weeks an examination of the plants sprayed showed that all had been injured by the treatment, the material having evidently been applied too strong. Tests at other places, reports of which were received after the tests here had been made, indicate the same thing, and it is now the intention to continue the experiments the coming season, to determine the best strength of the arsenite to use for effectiveness against insects and at the same time avoid injury to foliage, using various fruit and shade trees for the purpose.

It was noted in the course of the work that the arsenite did not remain long in suspension, and continuous agitation was necessary to insure an even distribution.

Zinc Arsenite. — Received from the California Spray Chemical Company, Watsonville, Cal., for trial. Tests of this were made at the same time and in the same way as with the other arsenite of zinc, as described above. The material appeared to settle rather more quickly than the other, but no other differences were noticed. It is evident that in this case, also, the application was too strong. It is quite certain that settling of both of the samples of arsenite of zinc can be materially delayed by the addition of soap, as has been shown by Parker (Montana Bulletin No. 86) and others.

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